smart™

Life Cycle Assessment

Study Completed: May - July, 2023
Critical Review Completed: September, 2023
Critical Review Completed By: WAP Sustainability

<table>
<tr><th colspan="7">LIFE CYCLE ASSESSMENT</th></tr>
<tr><td>Manufacturer</td><td colspan="6">Humanscale</td></tr>
<tr><td>Product Name(s)</td><td colspan="6">Diffrient Smart™, Smart™ Ocean, Smart™ Plus, Smart™ Conference</td></tr>
<tr><td>Product Type</td><td colspan="6">Task Chair/ Executive Chair/ Conference Chair</td></tr>
<tr><td>Product Description</td><td colspan="6">Featuring a unique linear design, the Diffrient Smart chair is ideal for any high design environment. Created with Humanscale's revolutionary FormSensing Mesh Technology, Diffrient Smart's tri-panel backrest fits like a perfectly tailored shirt to provide exceptional lumbar support. Using Humanscale's weight sensitive, self-locking recline mechanism, Diffrient Smart automatically adjust to each sitter and provides perfect support to any posture. Diffrient Smart is also available in Diffrient Smart Ocean which incorporates nearly 2 pounds of ocean plastic, Smart Plus with a wider seat and additional support and the luxurious Smart Conference which has a foam seat back upholstered in chrome-free leather.</td></tr>
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<tr><td rowspan="3">LCA Scope, Included Life Cycle Modules</td><td>Sourcing and Manufacturing Modules</td><td>Delivery and Installation Modules</td><td colspan="2">Use Phase Modules</td><td colspan="2">End of life Modules</td></tr>
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<tr><td rowspan="2">Reference Standards</td><td rowspan="2">☒ ISO 14040
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☐ EN 15804</td><td colspan="2">☐ Others (Specify Below):</td></tr>
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<tr><td>Reference PCR (If Applicable)</td><td colspan="4">BIFMA PCR for Seating: UNCPC 3811</td></tr>
<tr><td rowspan="2">LCA Study Conducted by</td><td>Date Completed</td><td colspan="3">September, 2023</td></tr>
<tr><td>LCA Practitioner</td><td colspan="3">Stephanie Richardson, Sustainability Manager, Humanscale</td></tr>
<tr><td rowspan="3">Independent LCA Review Details</td><td>Date of Final Approval</td><td colspan="3">26 September, 2023</td></tr>
<tr><td>LCA Reviewer</td><td colspan="3">Manasa Rao, Sustainability Manager, WAP Sustainability</td></tr>
<tr><td>Type of Review</td><td>☐ Internal</td><td colspan="2">☒ External</td></tr>
<tr><td>LCA Expiration Date</td><td colspan="4">25 September, 2026</td></tr>
<tr><td>LCA Software and Version</td><td colspan="4">OpenLCA</td></tr>
<tr><td>LCA Database(s) and Version(s)</td><td colspan="4">Ecoinvent database, version 3.8 cut off regionalized
AGRIBALYSE v3.0.1</td></tr>
<tr><td>Applicable Region(s)</td><td colspan="4">Global</td></tr>
<tr><td>Link to Publicly Available Version of LCA (If Applicable)</td><td colspan="4">https://www.humanscale.com/resources/designer-toolkit/green-design.cfm</td></tr>
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Diffrient Smart™

Smart™ Ocean

Smart™ Plus

Smart™ Conference

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1 EXECUTIVE SUMMARY

This critical review is being done by WAP Sustainability. The objective of the critical review is to ensure that this assessment meets the intent of the relevant imperatives within the Living Product Challenge; Water Footprint 04, Energy Footprint 06, and Net Positive Carbon 14, for greenhouse gas calculations for Scope 3, category 1: Purchased Goods and Services and to increase LEED credit contribution for this product.

The results presented herein will not be used as the sole basis for a comparative assertion.

2 GENERAL INFORMATION

2.1 COMPANY PROFILE

Humanscale was founded in 1983 by CEO Bob King with a focus on high-performance tools that support a healthy, more active way of working. Humanscale is now a global ergonomics and furniture leader with a reputation for designing intuitive products which improve the comfort and health of office workers. Humanscale's global headquarters is located in New York, NY and the company has offices and manufacturing throughout North America, Latin America & The Caribbean, Europe, Asia Pacific, Oceania, The Middle East and Africa.

- The LCA commissioner: Humanscale
- The LCA practitioner(s): Stephanie Richardson, Sustainability Manager; an employee of Humanscale.

The LCA modeling, results interpretation and report have been conducted according to the relevant requirements of the International Standards on LCA, including ISO 14040 and ISO 14044.

In addition, the LCA modeling, results interpretation and report have been conducted in conformance with established Product Category Rules (PCR). Specifically, this LCA followed the PCR for seating (BIFMA PCR for Seating - Version 3 UNCPC 3811).

2.2 REPORTING DATE

The LCA study commenced in May 2023 and a draft was submitted for critical review to WAP Sustainability in September 2023. The final approval of the document took place on 26 September 2023.

2.3 GOAL OF THE STUDY AND INTENDED APPLICATION

The intended application of this LCA is to support Humanscale in applying "life cycle thinking" to discover potential ways to further improve the environmental performance of the Smart™ chair family with a particular focus on one or more of the following impact categories: energy consumption, water consumption, and climate change, including the emissions and the possible sequestration of greenhouse gases.

Additionally, the study was also conducted to support the following certifications, reporting schemes and programs.

1. Living Product Challenge certification:
   Some of the certification criteria within Living Product Challenge, which are referred to as "imperatives", include a requirement related to the characterization of the product's cradle-to-gate footprint on specific impact categories. The required impact categories include climate change, water consumption and energy consumption. Additionally, the imperatives go on to call on manufacturers to identify the five major determinants, referred to as Hotspots, of a product's cradle-to-gate environmental footprints. Ultimately companies are required to establish plans to reduce these footprints and to create positive impacts (called "handprints") which are larger than the remaining footprint. Accomplishing the above requires a company to complete a life cycle assessment (LCA) on the products they are seeking certification for.
2. Greenhouse gas calculations for Scope 3, category 1: Purchased Good and Services:
   The LCA model and results will be used to calculate upstream Greenhouse Gas (GHG) impacts related to the production of Humanscale products. This calculation will then be used to disclosure Scope 3 emissions related to material extraction in Humanscale's annual Carbon Disclosure Project (CDP) submittal.
3. ANSI/BIFMA LEVEL e3 certification:
   LEVEL certification is based on the ANSI/BIFMA e3 standard and includes several credit points for calculation of product impacts through various phases of the life cycle. This LCA will be used to achieve these credits.
4. USGBC LEEDv4.1 MR credit:
   LEEDv4.1 awards point contribution to products that have a third-party verified LCA in accordance to ISO14040. The LCA must be publicly available and include a scope of at least cradle-to-gate. This LCA will be posted publicly and will be used by Humanscale to support their customer's point contribution to this credit.
5. Calculations toward Net Positive impact:
   Humanscale aims to have a net positive impact while manufacturing mass produced goods. Along with reductions in negative impacts from manufacturing, additional positive impacts are created with restorative initiatives. The LCA is used to understand the full amount of negative impacts, and therefore the minimum required amount of positive impacts required to achieve a state of net positive impact.

2.4 TARGET GROUP / AUDIENCE

The intended audience of the study includes:

- Customers, particularly those looking to achieve LEED credits related to product specific LCAs.
- Third-party verification professionals who will confirm compliance to ISO14040/44 and the product category PCR.
- Third-party verification professionals who will review the documentation to assure conformance to certifications and reporting schemes listed in the Goal and Intended Application section above.
- Employees of Humanscale who will use the LCA information to inform product design and company strategy.

2.5 COMPARATIVE ASSERTIONS AND PUBLIC DISCLOSURE

This LCA will be publicly available; however, this study was not completed with the intent that comparative assertions would be made using its results. Additionally, the study is not comparative in nature and only discloses the impacts associated with single products or groups of products and makes no claims of the environmental performance of the products in the study against other products.

2.6 ISO 14040/44 AND PCR COMPLIANCE

This LCA has been critically reviewed for compliance with;

- ISO 14040/44
- BIFMA PCR for Seating: UNCPC 3811, Version 3

The critical review statement and checklist are included in the appendix of this document.

3 SCOPE OF THE STUDY

3.1 FUNCTIONAL UNIT

The primary function of the product is to provide seating to one individual.

The functional unit for this LCA study follows the requirements for defining a function unit according to the BIFMA PCR for Seating: UNCPC 3811 version 3. This PCR states that "the functional unit shall be one unit of seating to seat one individual, maintained for a 10-year period." Although the warranty for the Smart™ chair family is 15 years, and they are expected to perform at least as long as its warranty period, this LCA follows the PCR requirement, and the functional life of the product is assumed to be ten years.

3.2 PRODUCT DESCRIPTION

3.2.1 Product Description and Specifications

Created with Humanscale's revolutionary FormSensing Mesh Technology, Diffrient Smart™'s tri-panel backrest provides exceptional lumbar support. Using Humanscale's weight sensitive, self-locking recline mechanism, Diffrient Smart™ automatically adjusts to each sitter and provides perfect support to any posture. Diffrient Smart™ is also available in Diffrient Smart™ Plus with a wider seat and additional support, Diffrient Smart™ Ocean which incorporates two pounds of recycled ocean plastic into each chair, and Smart Conference which has a foam seat back and is upholstered in chrome-free leather.

Model numbers for Diffrient Smart™ begin with 'S41', for Diffrient Smart™ Plus 'S21', for Smart™ Ocean with 'S11' and for Smart Conference with 'S61'.

All Diffrient Smart™ and Smart™ Ocean models have a die cast aluminum base, adjustable arms with foam pad, monofilament stripe mesh, standard seat cushion with Corde 4 seat upholstery, hard casters, and a standard cylinder. Smart Ocean utilizes 1.7 pounds of ocean plastic in the chair frame.

The Smart™ Plus models in this LCA report have a die cast aluminum base, fixed arms with foam pad, monofilament stripe mesh, 5.11 seat assembly with a larger seat cushion to support additional weight, hard casters, and a standard cylinder.

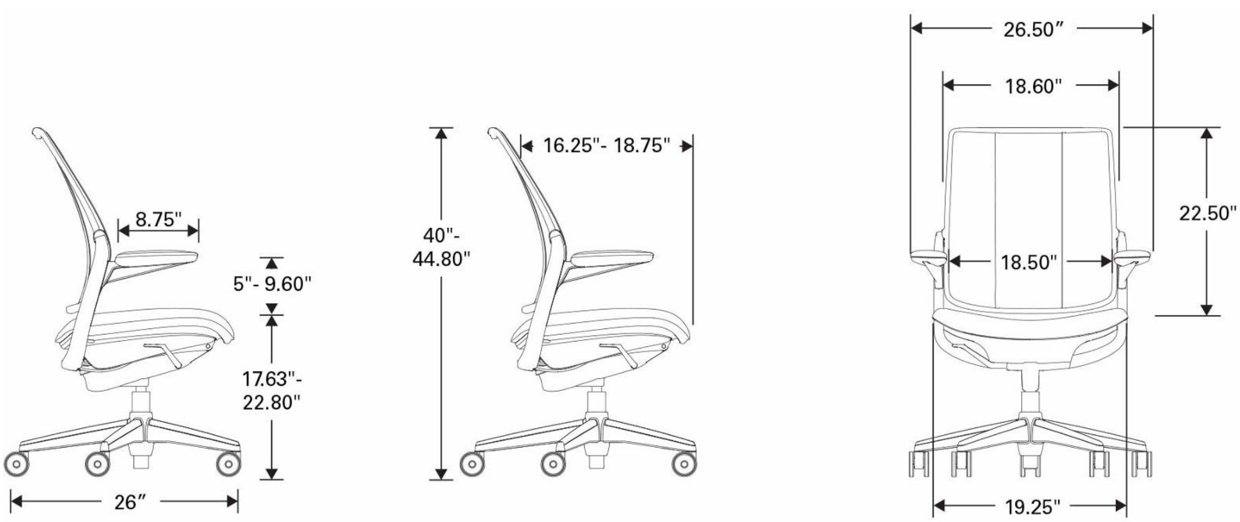
The Diffrient Smart™ and Diffrient Smart™ Plus have dark grey frames with polished aluminum finishes and the Diffrient Smart™ Ocean has a black frame with polished aluminum finish.

The Smart™ Conference model has a die cast aluminum base, fixed arms with foam pad, standard seat cushion, hard casters and standard cylinder. Smart Conference utilizes upholstered chrome-free leather throughout and has a foam back in place of a mesh one.

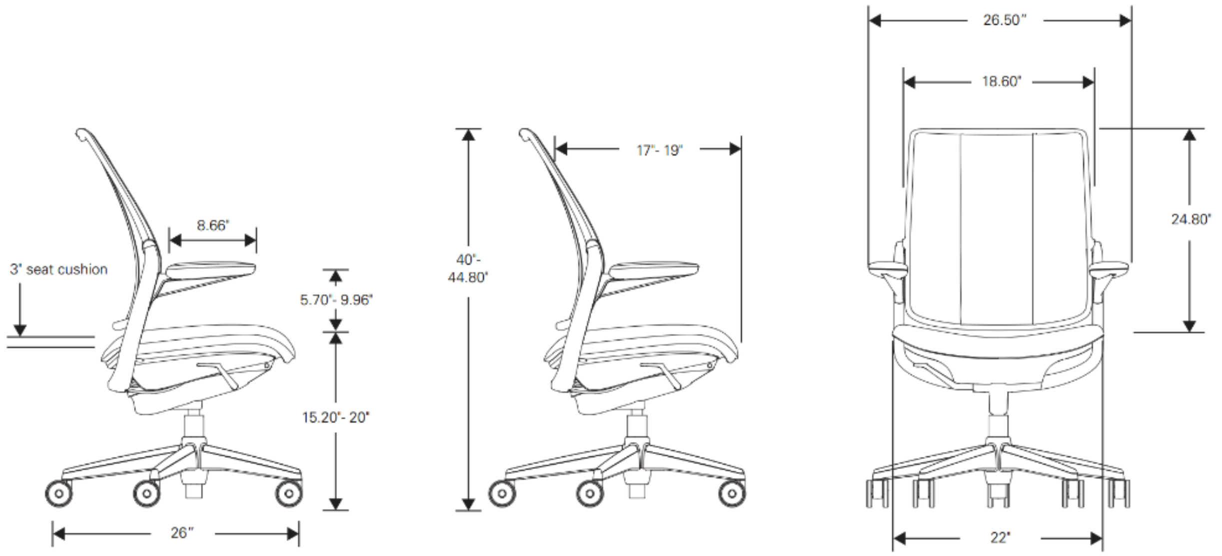
For this report, the most popular and impactful configurations were chosen. Data availability in the Ecoinvent database was also a factor in configuration selection.

Figure 1: Product Specifications

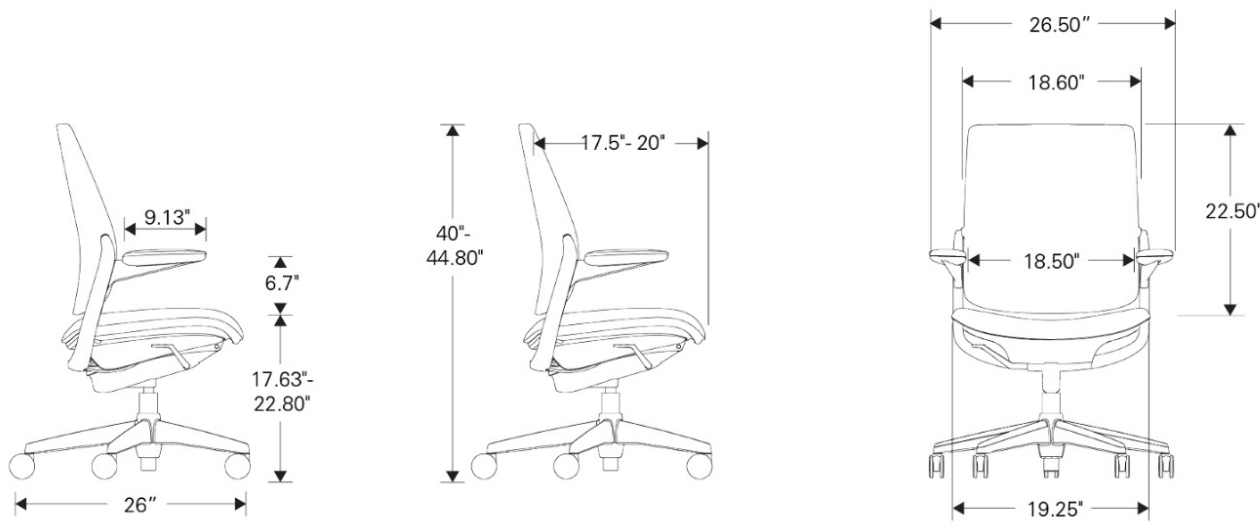
Diffrient Smart™ & Smart™ Ocean



Smart™ Plus



Smart™ Conference



3.2.2 Technical Data

Table 1: Technical Details	
ANSI/BIFMA X5.1	Certification # 20180803-MH62209
Sustainability certification	Living Product Challenge: HSC-LP001, HSC-LP002, HSC-LP003
	Declare: HSC-0044, HSC-0046, HSC-0047, HSC-00__
	ANSI/BIFMA LEVEL® 3: SCS-SCF-05108
	HPD Label: 27869
VOC emission	Indoor Advantage Gold: SCS-IAQ-05426

3.3 SYSTEM BOUNDARY

For full cradle-to-grave analysis, the upstream system boundary includes the full cradle-to-gate supply chains of all inputs beginning with material extraction and ending with final assembly of the product by Humanscale. The downstream system boundary begins with shipping of the product to the customer and terminates with product disposal which follows the solid waste treatment percentages of the most current version of the USEPA Municipal Solid Waste data for North America.

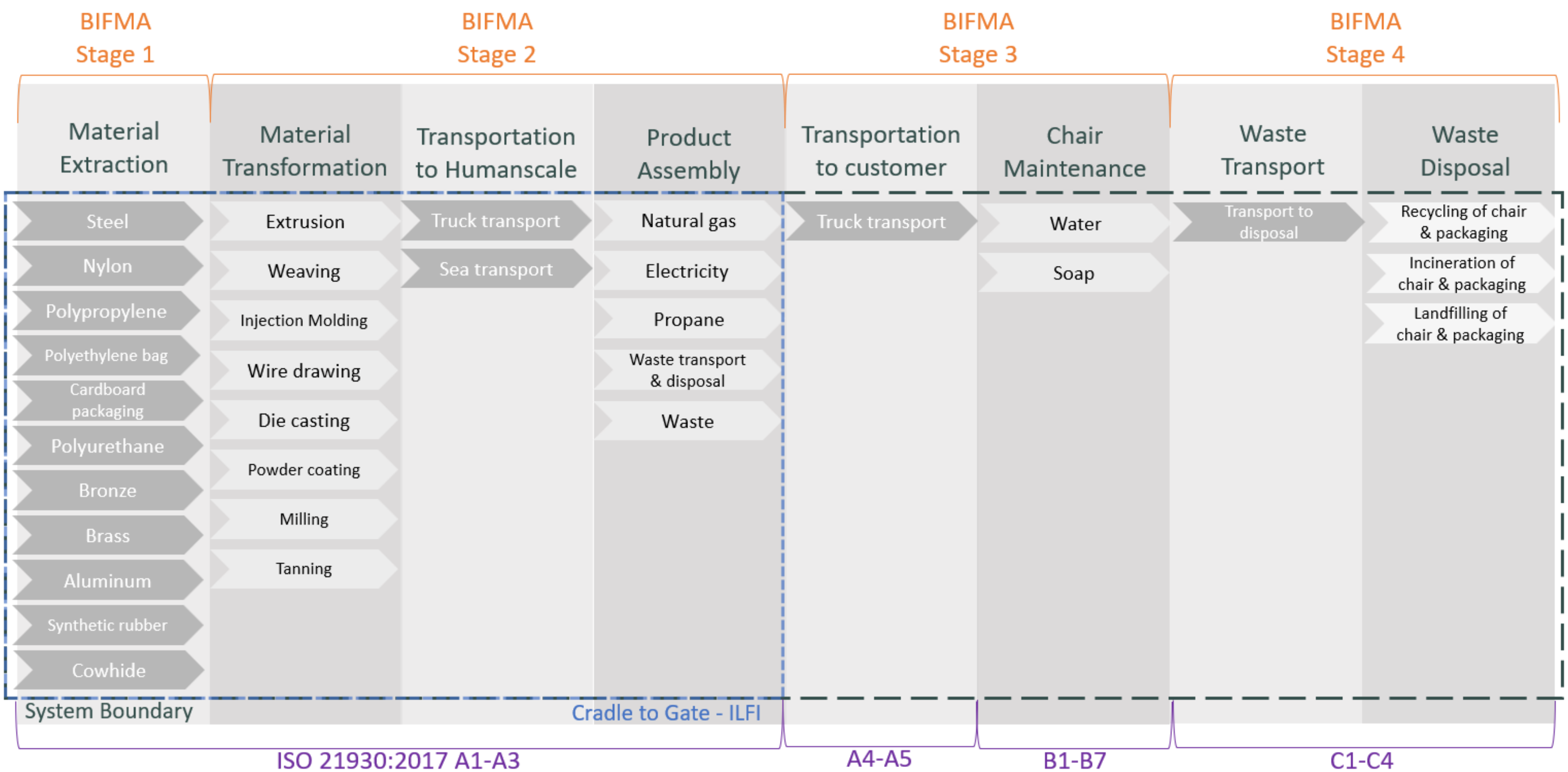
Table 2: Summary of Included Life Cycle Stages			
Module Name	BIFMA Seating PCR Life Cycle Stage Name	Analysis Period	Summary of Included Elements
Smart MatExtract	**Material Acquisition and Pre-processing**	2022	Raw material extraction, transportation and refining including packaging as defined by secondary data.
Smart MatTrans	**Production (Manufacturing / Assembly)**	2022	Manufacturing of components.
Smart Trspt to HS	**Production (Manufacturing / Assembly)**	2022	Transportation of product components to Humanscale. Primary data is used.
Assembly	**Production (Manufacturing / Assembly)**	2022	Final assembly and packing at Humanscale facility. Primary data is used for electricity, natural gas and waste.
Smart Trspt to Cust	**Distribution, storage, and use**	2022	Transportation to customer. Farthest shipping distance via frieght truck is assumed.

Chair Maintenance	**Distribution, storage, and use**	2022	Cleaning of product.
Smart EOL Trspt	**End of life**	2022	Transportation of product and product packaging to disposal facility.
Smart EOL Disposal	**End of Life**	2022	Landfilling and incernerating of packaging and product parts.

Figure 2: System Boundary Diagram shows the full scope of the model which has been developed using primary and secondary data. All secondary data used in the model have multiple inputs from the ecoinvent database, and ultimately the full system (with foreground and background data) contains thousands of unit processes.

The system model includes production of raw materials, as well as all inputs of energy, inbound transport, and waste, outbound transportation to customer, use phase, and end of life including transportation and treatment of waste. Water is not used in the final assembly of these Smart™ products except for the production of the seat cushion which is done by Humanscale with harvested rainwater on site.

Figure 2: System Boundary Diagram



3.4 MATERIAL ACQUISITION AND PRE-PROCESSING STAGE

This stage includes raw material extraction, transportation to suppliers' facilities, material refining including:

- Material extraction including scrap material
- Waste created during material processing, including the transportation of the waste created to landfill or recycling facility
- Material primary processing
- Interfacility transportation
- Materials used in packaging of the final product
- Transportation to the production stage

Table 3: Material Composition (grams)				
	Smart	Smart Ocean	Smart Plus	Smart Conference
Plastic	4,200.7	4,200.7	1,170.3	4,246.7
Polyurethane	760.6	760.6	4,204.4	1,050.5
Aluminum	8,185.6	8,185.6	8,186.8	8,691
Steel	2,700.6	2,700.6	2,945.8	2,656.7
Bronze	36.6	36.6	36.6	42.9
Brass	0	0	0	68
Packaging	6,063.4	6,063.4	6,063.4	11,738.8
Leather	0	0	0	835
Total	**21,947.5**	**21,947.5**	**22,607.3**	**29,329.5**

In this phase, primary data was used for the amount of scrap generated during each process. Humanscale has gathered scrap information from first-tier suppliers. This material has been accounted for in Section 3.4. For waste generation and transportation, default values within the ecoinvent dataset were used.

For transportation to the production stage, default values in the ecoinvent database were used.

3.5 PRODUCTION

This stage includes manufacturing of main parts and components, transportation to Humanscale location, final assembly and packaging, including:

- Manufacturing of main furniture components from basic raw materials
- Transportation to Humanscale's factory gate for assembly
- Transportation between Humanscale facilities, if applicable
- Product assembly, including the use of ancillary materials necessary for production, if applicable
- Product packaging
- Waste creation and processing
- Energy inputs

Preparation of the final product, including forming, surface treatment, machining and/or other processes are included as applicable.

In this phase, primary data for waste material transportation was calculated using the PCR required default value of 32 kilometers (20 miles) since primary data was not available. For secondary data, waste transportation values were embedded in the LCA dataset used.

In absence of primary data from Humanscale's leather supplier, and lack of leather tanning inputs in Ecoinvent and AGRIBALYSE v3.0.1 databases, we referenced a report published by the Department of Science and technology at the Parthenope University of Naples that evaluates the chrome and vegetable tanning processes. A model for vegetable tanning was built in OpenLCA utilizing the inputs and outputs table found in the report. Since the report did not break down the tannins used, we referenced a report published by the American Institute of Physics that evaluates the tanning agent in the leather industry. A model for vegetable tannin was built in OpenLCA utilizing the inputs found in Table 4 below.

Table 4: Tanning Process		
Flow	Amount	Unit
acetic acid	0.1	kg
bromine	1	kg
EDTA	0.2	kg
electricity, low voltage	1.7	kWh
formic acid	0.4	kg
hydrogen sulfide	0.8	kg
lime	0.2	kg
propane	4.5	kg
sodium bicarbonate	0.1	kg
sodium chloride, powder	2	kg
sodium oxide	0.5	kg
sodium sulfite	0.1	kg
steel, unalloyed	0.3	kg
sulfuric acid	0.1	kg
vegetable tannin	3.1	kg
wood chips	3.1	kg

Waste generated at Humanscale facilities were based on primary data. For secondary data, waste destination parameters were embedded within the datasets used.

The are no additional inputs beyond what has been accounted for in the product's raw materials that are required for the assembly and install of the product.

3.6 DISTRIBUTION, STORAGE, AND USE

This stage includes all materials, energy and waste related to product transport to customer and chair use/maintenance.

- Transportation from manufacturing gate to customer
- Product maintenance (cleaning with mild soap and water)

In some cases, the product is shipped to a distributor or dealer before being transported to the final customer. This is not included in the model, however, due to uncertainty and lack of primary data. As such, storage is not included. The models in this report assume the product is being shipped direct to the consumer. Transportation mode and distances in this phase were based on primary data. The value utilized represents the furthest customer from the assembly location. The average farthest shipping distance for both final assembly locations is 3,689 kilometers.

Additionally, aside from regular cleaning, there is no energy or additional inputs required for operation and use and the product does not change the operational efficiency of the building. This same statement can be said for water. Repair and refurbishment happens infrequently and did not need to be accounted for.

Per Humanscale's cleaning instructions for seating, the following inputs are included in the model during the product use phase over its lifespan;

Table 5: Use Phase Inputs		
Input	Dataset	Amount (grams)
water	Tap water, at user, ROW	59.2
mild soap	Soap production, ROW	187.2

3.7 END OF LIFE MANAGEMENT

This stage includes transportation of the product and packaging to the end of life facility. Even though Humanscale products are highly recyclable and come with disassembly instructions, the product is assumed to be landfilled, incinerated and recycled based on the BIFMA PCR and EPA Recycling Rates for North America. Collection of end of life product and packaging distances are based on the current USEPA WARM Model per the PCR. All waste materials are assumed to be disposed of in North America for products assembled in North America facilities. North American EPA data was used for end of life modeling in Dublin as well in absence of European-specific hauling distances and recycling rates.

Geographic specificity of the dataset used to represent product landfilling was global in nature.

Table 6: End of Life Management						
Product	Material Type	Weight (grams)	Recycling Rate*	Weight Recycled (grams)	Weight Landfilled (grams)**	Weight Incinerated (grams)**
Smart / Smart Ocean	Polypropylene	1,834.7	8.7%	158.9	1,340.7	335.2
	Polyurethane	760.6	8.7%	65.9	555.8	139
	Other plastic	2,476	8.7%	214	1,809.3	452.3
	Steel (ferrous)	2,700.6	33%	894.6	1,444.8	361.2
	Aluminum	8,222.2	17%	1,416	5,444.8	1,361.2
	Paperboard	5,953	68%	4,061	1,513.8	378.5
Smart Plus	Polypropylene	2,017	8.7%	174.7	1,473.9	368.5
	Polyurethane	1,170	8.7%	101.4	855.2	213.8
	Other plastic	2,297	8.7%	199	1,678.8	419.7
	Steel (ferrous)	2,945.8	33%	975.8	1,576	394
	Aluminum	8,223	17%	1,416.4	5,445.6	1,361

	Paperboard	5,953	68%	4,061.1	1,513.8	378.4
Smart Conference	Leather	835	18%	152.2	546.21	136.6
	Polypropylene	1,844.7	8.7%	159.8	1,348	337
	Polyurethane	1,050.5	8.7%	91	767.6	191.9
	Other plastic	2,313.5	8.7%	200	1,690.5	422.6
	Steel (ferrous)	2,656.7	33%	880	1,421.3	355.3
	Aluminum	8,801.9	17%	1,516	5,828.7	1,457.2
	Paperboard	11,729.7	68%	8,001	2,982.6	745.7

*Recycling rates from the 2018 EPA Sustainable Materials Management (SMM) – Materials and Waste Management in the United States Key Facts and Figures.
** Per the PCR, 80% of the material not recycled should be modeled using landfill and 20% using incineration.

3.8 CUT-OFF CRITERIA

This LCA follows the cut-off criteria required by the BIFMA PCR for Seating, which allows flows less than 1% to be omitted if their omission is justified. Cumulatively all mass and energy omitted cannot exceed 5%.

For this study, Humanscale attempted to include all known mass and energy flows. Some flows were omitted due to data quality restrictions. Specially, the following flows were omitted:

- The system model omits the tape used in packaging because the Ecoinvent database does not have this input material, nor could one be found that was close enough for use as a substitute. The tape that was omitted was 9.07 grams, less than .1% of the product weight for all four chairs.
- POM components are also omitted for the same reason. In total, the POM weighs 88.42 grams for Smart Conference and 88.9 grams for Smart, Smart Ocean and Smart Plus. In total, the POM that is omitted makes up less than 0.5% of the product weight for all four chairs.
- In total, the system model omits less than 1% of all four chairs' weight.

3.9 ALLOCATION PROCEDURES

For primary data, mass allocation was used to model waste and energy inputs. For this, the total weight of the chair was divided by the total weight of all products produced in the Humanscale facility during the 2022 calendar year to proportionately allocate waste and energy. For background processes we used the Ecoinvent database, version 3.8 cut-off regionalized.

3.10 DATA QUALITY REQUIREMENTS

3.10.1 Geographical Coverage

Final manufacturing of the products occurs in two Humanscale facilities in North America and one in Europe and the product is shipped to customers globally. For the purpose of this report, six models have been created to represent the impacts of the Smart™ family specific to its final assembly location and their supply chains. Diffrient Smart™ Task and Smart™ Ocean are made at two facilities. Smart™ Plus and Smart™ Conference are only made in our New Jersey facility.

United States	Ireland
220 Circle Dr N, Piscataway, NJ 08854	IDA Industrial Estate Poppinntree Finglas Dublin 11

3.10.2 Time Coverage

The study is meant to reflect current conditions, using primary data from the most recent full calendar year available, 2022.

3.10.3 Technical Coverage

Primary data was retrieved from Humanscale utility and waste hauling bills from the most current complete calendar year (2022), is site-specific and considered of good quality. The energy used in manufacturing includes the overhead energy (lighting, heating, etc.) of the entire facility. Sub-metering was not available to extract process energy use from the total energy use. Sub-metering would improve the technological coverage of data quality.

For secondary data, we use the most current version of the Ecoinvent database, version 3.8 and AGRIBALYSE, version 3.1.

In cases where proxy data must be used, we compare the available options and use the most conservative option (the one which yields higher cradle-to-gate impacts on one or more of the three impact categories indicated in the goal and scope). Secondary data used in this study are listed in Table 5 below. In general, secondary data was of overall good quality, however regional specificity was lacking. This was due to the lack of availability of regionally specific data in the ecoinvent database. Additionally, for cases in which available databases lacked specific inputs and proxies, Humanscale created these inputs using information from available publications. Availability of primary data for would have been ideal but was not available.

Table 7: Secondary Dataset Reference					
Dataset	Source	Time Coverage	Geographical Coverage	Technical Coverage	Overall Representativeness
market for aluminium scrap, new | Cutoff, U	Ecoinvent	2010	RER	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for aluminium scrap, post-consumer, prepared for melting Cutoff, U	Ecoinvent	2011	GLO	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for acrylonitrile-butadiene-styrene copolymer | Cutoff, U	Ecoinvent	2021	GLO	Appropriate technology	Good, appropriate technology but not exact timeframe, nor geography
market for aluminium, primary, ingot | Cutoff, U	Ecoinvent	2019	IAI Area, North America	Appropriate technology	Good, appropriate technology but not exact timeframe
market for aluminium, primary, ingot | Cutoff, U	Ecoinvent	2015	China	Appropriate technology	Good, appropriate technology but not exact timeframe
market for brass | Cutoff, U	Ecoinvent	2011	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe, nor geography
Market for bronze | Cutoff, U	Ecoinvent	2021	GLO	Appropriate technology	Good, appropriate technology but not exact geography
market for corrugated board box production (updated to reflect local electricity grid)	Ecoinvent	2013	US RFC	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for iron scrap, sorted, pressed | Cutoff, U	Ecoinvent	2011	RoW	Used as proxy for recycled steel	Fair
market for nylon 6 | Cutoff, U	Ecoinvent	2011	RoW	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for nylon 6, glass-filled | Cutoff, U	Ecoinvent	2011	RoW	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for nylon fibre | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2013	KR	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for polyester fibre | Cutoff, U	Ecoinvent	2021	GLO	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe

market for packaging film, low density polyethylene | Cutoff, U	Ecoinvent	2011	GLO	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for plastic granulate, unspecified, recycled | Cutoff, U	Ecoinvent	2017	IN	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for polyethylene, high density, granulate | polyethylene, high density, granulate | Cutoff, U	Ecoinvent	2011	GLO	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for polypropylene, granulate | Cutoff, U	Ecoinvent	2011	GLO	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
polyurethane production, flexible foam, MDI-based | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2020	US-RFC	Appropriate technology	Good, appropriate technology but not exact geography
polyurethane production, flexible foam, MDI-based | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2020	TW	Appropriate technology	Good, appropriate technology but not exact geography
market for steel, unalloyed | Cutoff, U	Ecoinvent	2011	GLO	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for synthetic rubber | Cutoff, U	Ecoinvent	2011	GLO	Used as a proxy for TPE	Fair
market for waste paperboard, sorted | Cutoff, U	Ecoinvent	2013	GLO	Appropriate technology	Good, appropriate technology but not exact geography
steel milling, small parts | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2010	RoW	Used as proxy for machining	Fair
steel milling, small parts | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2010	US-RFC	Used as proxy for machining	Fair
steel milling, small parts | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2010	US-NPCC	Used as proxy for machining	Fair
steel milling, small parts | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2010	CN	Used as proxy for machining	Fair
steel milling, small parts | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2010	MX	Used as proxy for machining and stamping	Fair
coating powder production | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe

coating powder production | Cutoff, U	Ecoinvent	2010	RoW	Used as proxy for painting	Fair
magnesium-alloy production, AZ91, diecasting | Cutoff, U (updated to reflect local electricity grid and removed material input)	Ecoinvent	2010	RER	Used as proxy for aluminum and steel diecasting	Fair
casting, bronze| Cutoff, U (updated to reflect local electricity grid and removed material input)	Ecoinvent	2023	MX	Used as proxy for sintering	Fair
casting, bronze| Cutoff, (updated to reflect local electricity grid and removed material input)	Ecoinvent	2023	US - RFC	Used as proxy for sintering	Fair
market for impact extrusion of steel, cold, 1 strokes | Cutoff, U	Ecoinvent	2011	GLO	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
injection moulding | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2013	CN	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
injection moulding | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2013	TW	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
injection moulding | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2013	MX	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
injection moulding | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2013	US-RFC	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
injection moulding | Cutoff, U (updated to reflect local electricity grid)	Ecoinvent	2013	CA-QC	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
weaving of synthetic fibre, for industrial use | Cutoff, U	Ecoinvent	2019	GLO	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
wire drawing, steel | Cutoff, U	Ecoinvent	2021	RoW	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for acetic acid, without water, in 98% solution state | Cutoff, U	Ecoinvent	2021	GLO	Appropriate technology	Good, appropriate technology but not exact geography
market for bark chips, wet, measured as dry mass | Cutoff, U	Ecoinvent	2021	Europe without Switzerland	Appropriate technology	Good, appropriate technology but not exact geography
market for bromine | Cutoff, U	Ecoinvent	2021	GLO	Appropriate technology	Good, appropriate technology but not exact geography

market for EDTA, ethylenediaminetetraacetic acid | Cutoff, U	Ecoinvent	2021	GLO	Appropriate technology	Good, appropriate technology but not exact geography
market for formic acid | Cutoff, U	Ecoinvent	2021	RER	Appropriate technology	Good, appropriate technology but not exact geography
market for hydrogen sulfide | Cutoff, U	Ecoinvent	2021	RER	Appropriate technology	Good, appropriate technology but not exact geography
market for lime | Cutoff, U	Ecoinvent	2021	RER	Appropriate technology	Good, appropriate technology but not exact geography
market for lime | Cutoff, U	Ecoinvent	2021	RER	Appropriate technology - used as neutralizing agent	Good, appropriate technology but not exact geography
market for sodium bicarbonate | Cutoff, U -	Ecoinvent	2021	GLO	Appropriate technology	Good, appropriate technology but not exact geography
market for sodium chloride, powder | Cutoff, U	Ecoinvent	2021	GLO	Appropriate technology	Good, appropriate technology but not exact geography
market for sodium oxide | Cutoff, U	Ecoinvent	2021	RER	Appropriate technology	Good, appropriate technology but not exact geography
market for sodium sulfite | Cutoff, U	Ecoinvent	2021	RER	Appropriate technology	Good, appropriate technology but not exact geography
market for sulfuric acid | Cutoff, U	Ecoinvent	2021	RER	Appropriate technology	Good, appropriate technology but not exact geography
market for tap water | Cutoff, U	Ecoinvent	2021	Europe without Switzerland	Appropriate technology	Good, appropriate technology but not exact geography
meat, cowhide, spreadable materials and SPA C1,2,3, from beef	Agribalyse	2012	FR	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U	Ecoinvent	2019	RER	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
transport, freight, sea, bulk carrier for dry goods | Cutoff, U	Ecoinvent	2018	GLO	Appropriate technology	Good, appropriate technology but not exact geography nor timeframe
market for electricity, low voltage | Cutoff, U	Ecoinvent	2012	SE	Appropriate technology	Fair, appropriate technology but not exact timeframe
market for electricity, low voltage | Cutoff, U	Ecoinvent	2012	IE	Appropriate technology	Fair, appropriate technology but not exact timeframe

market for electricity, low voltage | Cutoff, U	Ecoinvent	2012	US-RFC	Appropriate technology	Fair, appropriate technology but not exact timeframe
electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted | Cutoff, U	Ecoinvent	2012	US-RFC	Appropriate technology	Fair, appropriate technology but not exact timeframe
municipal waste collection service by 21 metric ton lorry | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Fair, appropriate technology but not exact geography nor timeframe
market for natural gas, low pressure | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Fair, appropriate technology but not exact geography nor timeframe
natural gas production | propane | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Fair, appropriate technology but not exact geography nor timeframe
market for soap | Cutoff, U	Ecoinvent	2011	GLO	Appropriate technology	Good, appropriate technology but not exact timeframe
market for tap water | Cutoff, U	Ecoinvent	2014	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of municipal solid waste, sanitary landfill | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of municipal solid waste, incineration | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of scrap aluminium, municipal incineration | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of scrap steel, municipal incineration | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of scrap steel, inert material landfill | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of waste aluminium, sanitary landfill | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of waste paperboard, municipal incineration | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of waste paperboard, sanitary landfill | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of waste plastic, mixture, municipal incineration | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of waste plastic, mixture, sanitary landfill | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe

treatment of waste polypropylene, sanitary landfill | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of waste polypropylene, municipal incineration | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of waste polyurethane, sanitary landfill | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe
treatment of waste polyurethane, municipal incineration | Cutoff, U	Ecoinvent	2010	RoW	Appropriate technology	Good, appropriate technology but not exact timeframe

3.10.4 Treatment of Missing Data

We leave the amount of upstream supply chain electricity used in modeling (embedded within the background database) unaltered. However, we updated the source of the electricity in some upstream models to reflect the electricity grid local to our suppliers to improve geographic specificity of the model. The recycled content amounts are supplied to Humanscale directly from the vendor of each material. We did not have primary data on customer use, however it was assumed that the customer will wash their Smart™ chairs in accordance with Humanscale's Cleaning Instructions for Humanscale Seating Products. All Humanscale products come with Disassembly Instructions and are highly recyclable, however per the PCR, the model assumes the product is landfilled, incinerated and recycled based on the current USEPA WARM Model.

3.10.5 Completeness

No flows were knowingly excluded from the study. Cumulatively all mass and energy omitted cannot exceed 5%.

3.10.6 Precision

Precision of this study is considered reasonable because primary product data is pulled from product bill of materials. Primary facility data was retrieved from Humanscale utility and waste hauling bills, is site-specific and considered of good quality. The energy used in manufacturing includes power tools and the overhead energy (lighting, heating, etc.) of the entire facility.

For secondary data, we use the most current version of the Ecoinvent database, version 3.8 and AGRIBALYSE, version 3.1

3.10.7 Consistency

Bill of materials are provided by our product engineers, maintained and updated as needed. Products come with assembly instructions and maintenance guidelines that are publicly available. Assumptions and value judgements are consistent throughout the study.

3.10.8 Reproducibility

This report is transparent and discloses the data and assumptions made throughout. This would allow another practitioner to produce similar results for the potential environmental impacts of these products.

3.10.9 Uncertainty

There were some uncertainties within the study. Because of this, a sensitivity analysis was completed for areas in which we could evaluate further. These uncertainties include;

- Utilizing proxies where material or process flows are not available
- Using mass allocation to account for the products' contribution to the waste, water, and energy inputs during assembly at Humanscale's manufacturing locations.
- The models in this report assume that the task chairs are being shipped to the furthest customer relative to their manufacturing location.
- Uncertainty of the leather modeling process. In absence of primary data from Humanscale's leather supplier, and lack of leather tanning inputs in Ecoinvent and AGRIBALYSE databases, we referenced a report published by the Department of Science and Technology at the Parthenope University of Naples that evaluates the chrome and vegetable tanning processes. A model for chrome-free vegetable tanning was built in OpenLCA utilizing the inputs and outputs table found in the report. Since the report did not breakdown the tannins used, we referenced a report published by the American Institute of Physics that evaluates the tanning agent in the leather industry. A model for vegetable tannin was built in OpenLCA utilizing the inputs and outputs table found in the report.

4 LIFE CYCLE INVENTORY ANALYSIS

4.1 DATA COLLECTION AND CALCULATION PROCEDURES

Primary data was used for all bill-of-material items, as well as all inputs of energy, inbound transport, waste, and outbound transportation.

Primary data were obtained from the following sources. Solidworks CAD models were used to provide a full bill of materials, listing each part, it's material, and part weight. Infor, Humanscale's ERP system, which is used for ordering components, provided the name of supplier, their address, and common shipping method for all components ordered. Trucking distances were calculated using Google Maps, and ocean freight distances were estimated by using Sea-Distances.org. Amount of scrap was provided by the suppliers directly or estimated. Energy use in the facility of final assembly was calculated based on primary data.

Neither normalization nor weighting have been used in this study. Results are presented at the midpoint level. We include the ISO-required LCIA disclaimer here: "ISO 14044 does not specify any specific methodology or support the underlying value choices used to group the impact categories. Any value-choices and judgments embedded within the grouping procedures are the sole responsibilities of the commissioner of the study (e.g. government, community, organization, etc.)"

4.2 LIMITATIONS OF THE STUDY

LCA is a method used to assess potential rather than actual impacts. Consistent with our Goal and Scope, we obtained primary data for the final manufacturing step, and used secondary data for the background processes including the supply chain processes.

Due to the assumptions and value choices listed above, these do not reflect real-life scenarios and hence they cannot assess actual and exact impacts, but only potential environmental impacts. The results presented here should not be used as-is in a comparative assessment with competing products.

Some limitations to the study have been identified as follows:

- A significant limitation of the study was the availability of geographically appropriate datasets. More accurate datasets would have improved the accuracy of the study.
- Availability of primary data for suppliers' energy use, waste and transportation values would have been ideal but was not available.
- The system model omits the tape used in packaging and POM used in various chair components because the Ecoinvent database does not have these input materials, nor could we find alternatives that were close enough for use as a substitute. The tape that was omitted was 9.07 grams, less than 0.1% of the product weight for both chairs. The POM that was omitted weighs 88.42 grams for Smart Conference and 88.9 grams for Smart, Smart Ocean and Smart Plus. In total, the POM that is omitted makes up less than 0.5% of the product weight for all four chairs.
- Uncertainty of the leather modeling process. In absence of primary data from Humanscale's leather supplier, and lack of leather tanning inputs in Ecoinvent and AGRIBALYSE v3.0.1 databases, we referenced a report published by the Department of Science and technology at the Parthenope University of Naples that evaluates the chrome and vegetable tanning processes. A model for vegetable tanning was built in OpenLCA utilizing the inputs and outputs table found in the report. Since the report did not break down the tannins used, we referenced a report published by the American Institute of Physics that evaluates the tanning agent in the leather industry. A model for vegetable tannin was built in OpenLCA utilizing the inputs and outputs table found in the report.

5 LIFE CYCLE IMPACT ASSESSMENT

5.1 SELECTION OF IMPACT PARAMETERS

Environmental Impacts were calculated using the OpenLCA software platform. Impact results have been calculated using both TRACI 2.1 and ReCiPe 2016 Midpoint (H) characterization factors. This LCA uses TRACI 2.1 per the requirements of the BIFMA PCR. ReCipe 2016 Midpoint (H) is also used as it is required by ILFI. Specific impact parameters were selected based on the requirements of the ILFI Living Product Challenge Certification requirements and requirements listed for LCA in the LEED V4.1 standard. Per ISO 14040/44: LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Table 8: Impact Parameters			
Requirement of	Abbreviation	Parameter	Unit
TRACI 2.1			
BIFMA	AP	Acidification Potential	kg SO2 eq
BIFMA	EP	Eutrophication Potential	kg N eq
BIFMA / ILFI	GWP	Global Warming Potential	kg CO2 eq
BIFMA	OD	Ozone Depletion	kg CFC-11 eq
BIFMA	Smog	Smog	kg O3 eq
ReCiPe 2016 Midpoint (H)			
ILFI	WC	Water Consumption	m3
ILFI	FS	Fossil Resource Scarcity	kg oil eq

5.2 LCA RESULTS

All results are given per functional unit as stated in in Section 3.1, which is one chair to provide seating to one individual.

5.2.1 Smart™

Table 9: Smart Piscataway LCA Results

		LPC Boundary				
Method	**Impact Category**	**Material Acquisition and Pre-processing**	**Production (Manufacturing / Assembly)**	**Distribution, storage, and use**	**End of Life**	**Cradle to Grave Total**
TRACI 2.1	AP (kg SO2 eq)	1.46E-01	1.73E-01	6.05E-02	8.30E-03	3.88E-01
	EP (kg N eq)	8.23E-02	9.90E-02	4.71E-02	7.05E-02	2.99E-01
	GWP (kg CO2 eq)	3.45E+01	3.54E+01	1.39E+01	5.64E+00	8.95E+01
	OD (kg CFC 11 eq)	1.56E-06	2.88E-06	3.29E-06	2.63E-07	7.99E-06
	Smog (kg O3 eq)	1.92E+00	2.57E+00	1.47E+00	2.05E-01	6.17E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	4.76E-01	2.01E-01	7.87E-02	6.96E-03	7.63E-01
	FS (kg oil-Eq)	1.12E+01	9.15E+00	4.62E+00	4.10E-01	2.54E+01

Table 10: Smart Dublin LCA Results						
		LPC Boundary				
Method	Impact Category	Material Acquisition and Pre-processing	Production (Manufacturing / Assembly)	Distribution, storage, and use	End of Life	Cradle to Grave Total
TRACI 2.1	AP (kg SO2 eq)	1.46E-01	1.86E-01	6.24E-02	8.30E-03	4.03E-01
	EP (kg N eq)	8.23E-02	9.71E-02	4.75E-02	7.05E-02	2.97E-01
	GWP (kg CO2 eq)	3.45E+01	3.56E+01	1.43E+01	5.64E+00	9.01E+01
	OD (kg CFC 11 eq)	1.56E-06	2.67E-06	3.39E-06	2.63E-07	7.89E-06
	Smog (kg O3 eq)	1.92E+00	2.75E+00	1.52E+00	2.05E-01	6.40E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	4.76E-01	1.96E-01	7.94E-02	6.96E-03	7.59E-01
	FS (kg oil-Eq)	1.12E+01	9.18E+00	4.77E+00	4.10E-01	2.56E+01

5.2.2 Smart™ Ocean

Table 11: Smart Ocean Piscataway LCA Results							
		LPC Boundary					
Method	Impact Category	Material Acquisition and Pre-processing	Production (Manufacturing / Assembly)	Distribution, storage, and use	End of Life	Cradle to Grave Total
TRACI 2.1	AP (kg SO2 eq)	1.20E-01	1.73E-01	6.05E-02	8.30E-03	3.62E-01
	EP (kg N eq)	7.78E-02	9.98E-02	4.71E-02	7.05E-02	2.95E-01
	GWP (kg CO2 eq)	2.76E+01	3.62E+01	1.39E+01	5.64E+00	8.34E+01
	OD (kg CFC 11 eq)	1.56E-06	3.06E-06	3.29E-06	2.63E-07	8.17E-06
	Smog (kg O3 eq)	1.56E+00	2.61E+00	1.47E+00	2.05E-01	5.85E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	3.71E-01	2.02E-01	7.87E-02	6.96E-03	6.59E-01
	FS (kg oil-Eq)	9.21E+00	9.42E+00	4.62E+00	4.10E-01	2.37E+01

Table 12: Smart Ocean Dublin Results						
		LPC Boundary				
Method	Impact Category	Material Acquisition and Pre-processing	Production (Manufacturing / Assembly)	Distribution, storage, and use	End of Life	Cradle to Grave Total
TRACI 2.1	AP (kg SO2 eq)	1.20E-01	1.86E-01	6.24E-02	8.30E-03	3.77E-01
	EP (kg N eq)	7.78E-02	9.76E-02	4.75E-02	7.05E-02	2.93E-01
	GWP (kg CO2 eq)	2.76E+01	3.60E+01	1.43E+01	5.64E+00	8.37E+01
	OD (kg CFC 11 eq)	1.56E-06	2.79E-06	3.39E-06	2.63E-07	8.01E-06
	Smog (kg O3 eq)	1.56E+00	2.77E+00	1.52E+00	2.05E-01	6.06E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	3.71E-01	1.97E-01	7.94E-02	6.96E-03	6.55E-01
	FS (kg oil-Eq)	9.21E+00	9.36E+00	4.77E+00	4.10E-01	2.38E+01

5.2.3 Smart™ Plus

Table 13: Smart Plus Piscataway Results						
		LPC Boundary				
Method	**Impact Category**	**Material Acquisition and Pre-processing**	**Production (Manufacturing / Assembly)**	**Distribution, storage, and use**	**End of Life**	**Cradle to Grave Total**
TRACI 2.1	AP (kg SO2 eq)	1.45E-01	1.74E-01	6.22E-02	8.65E-03	3.90E-01
	EP (kg N eq)	9.13E-02	1.01E-01	4.75E-02	8.01E-02	3.20E-01
	GWP (kg CO2 eq)	3.51E+01	3.57E+01	1.43E+01	5.91E+00	9.10E+01
	OD (kg CFC 11 eq)	1.85E-06	2.95E-06	3.38E-06	2.72E-07	8.45E-06
	Smog (kg O3 eq)	1.92E+00	2.59E+00	1.51E+00	2.16E-01	6.23E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	5.57E-01	1.81E-01	7.94E-02	7.35E-03	8.25E-01
	FS (kg oil-Eq)	1.19E+01	9.27E+00	4.76E+00	4.24E-01	2.64E+01

5.2.4 Smart™ Conference

Table 14: Smart Conference Piscataway Results						
		LPC Boundary				
Method	Impact Category	Material Acquisition and Pre-processing	Production (Manufacturing / Assembly)	Distribution, storage, and use	End of Life	Cradle to Grave Total
TRACI 2.1	AP (kg SO2 eq)	3.04E-01	2.62E-01	7.96E-02	1.09E-02	6.57E-01
	EP (kg N eq)	1.55E-01	1.38E-01	5.15E-02	9.06E-02	4.35E-01
	GWP (kg CO2 eq)	5.62E+01	5.21E+01	1.82E+01	8.19E+00	1.35E+02
	OD (kg CFC 11 eq)	2.29E-06	4.78E-06	4.36E-06	3.43E-07	1.18E-05
	Smog (kg O3 eq)	3.43E+00	3.66E+00	1.94E+00	2.68E-01	9.30E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	5.75E-01	9.93E-01	8.61E-02	8.72E-03	1.66E+00
	FS (kg oil-Eq)	1.52E+01	7.25E-01	6.13E+00	5.30E-01	3.17E+01

5.3 TOP 5 PROCESSES CONTRIBUTING TO ENERGY CONSUMPTION

In connection with the Living Product Challenge Impetrative 06 Energy Footprint, the table below presents the five processes that make the largest contributions to the cradle-to-gate (as defined by the ILFI) energy footprint of the Smart™ chair family. From the results below, it is clear that virgin glass-filled nylon used primarily in the back frame and arms are a significant contributor to the products' cradle to gate energy footprint. Diecasting aluminum also ranks high on the list. The chairs' back support, base, tilt pivot, and direct lever basic housing are significant aluminum components of the chairs that are die casted. Furthermore, the relative impacts of the top contributors are roughly the same across both assembly locations for these products with the exception of the leather tanning process related to the production of Smart™ Conference. Smart™ Conference is upholstered in chrome-free leather, the tanning process of which contributes 26.7% of the cradle-gate energy consumption required to manufacture the chair.

Table 15: Top 5 Processes Contributing to Energy Consumption ReCiPe 2016 Midpoint (H)

	Final Assembly Location	Process	%	Kg oil-Eq
Smart	Piscataway, NJ	market for nylon 6, glass-filled	17.63%	3.59E+00
		diecasting aluminum	16.68%	3.39E+00
		market for polypropylene, granulate	10.11%	2.06E+00
		injection molding	9.08%	1.85E+00
		steel milling, small parts	8.66%	1.76E+00
	Dublin, IE	market for nylon 6, glass-filled	17.6%	3.59E+00
		diecasting aluminum	16.65%	3.39E+00
		market for polypropylene, granulate	10.09%	2.06E+00
		injection molding	9.06%	1.85E+00
		steel milling, small parts	8.65%	1.76E+00
Smart Ocean	Piscataway, NJ	diecasting aluminum	18.22%	3.39E+00
		market for polypropylene, granulate	11.04%	2.06E+00
		injection molding	9.91%	1.85E+00
		steel milling, small parts	9.46%	1.76E+00
		market for nylon 6, glass-filled	9.02%	1.68E+00
	Dublin, IE	diecasting aluminum	18.28%	3.39E+00
		market for polypropylene, granulate	11.08%	2.06E+00
		injection molding	9.95%	1.85E+00
		steel milling, small parts	9.49%	1.76E+00
		market for nylon 6, glass-filled	9.05%	1.68E+00
Smart Plus	Piscataway, NJ	diecasting aluminum	15.72%	3.33E+00
		market for nylon 6, glass-filled	14.68%	3.11E+00
		polyurethane production, flexible foam	11.82%	2.50E+00
		market for polypropylene	10.82%	2.29E+00
		injection molding	8.88%	1.88E+00

Smart Conference	Piscataway, NJ	vegetable tanning	26.72%	9.15E+00
		market for nylon 6, glass-filled	11.96%	4.10E+00
		diecasting aluminum	11.34%	3.89E+00
		market for aluminum production	11.31%	3.88E+00
		polyurethane production, flexible foam	6.56%	2.25E+00

5.4 TOP 5 PROCESSES CONTRIBUTING TO CARBON FOOTPRINT

In connection with the Living Product Challenge Impetrative 14 Net Positive Carbon, the table below presents the five processes that make the largest contributions to the cradle-to-gate (as defined by the ILFI) carbon footprint of the Smart™ chair family. Like their embodied energy footprints, virgin glass-filled nylon and diecasting aluminum are significant contributors to the chairs' embodied carbon values. Steel milling of small parts used as a proxy for machining and stamping is another top contributor Furthermore, the relative impacts of the top contributors are roughly the same across both assembly locations for the Smart™ chairs with the exception of vegetable tanning contributing 11.9% of Smart Conference's embodied carbon footprint.

Table 16: Top 5 Processes Contributing to Carbon Footprint
TRACI 2.1

	Final Assembly Location	Process	%	KgCO2eq
Smart	Piscataway, NJ	diecasting aluminum	22.57%	1.58E+01
		market for nylon 6, glass-filled	17.91%	1.25E+01
		steel milling, small parts	11.01%	7.70E+00
		injection molding	8.17%	5.72E+00
		market for steel, unalloyed	6.23	4.36E+00
	Dublin, IE	diecasting aluminum	22.51%	1.58E+01
		market for nylon 6, glass-filled	17.87%	1.25E+01
		steel milling, small parts	10.98%	7.70E+00
		injection molding	8.15%	5.72E+00
		market for steel, unalloyed	6.22%	4.36E+00
Smart Ocean	Piscataway, NJ	diecasting aluminum	24.73%	1.58E+01
		steel milling, small parts	12.07%	7.70E+00
		market for nylon 6, glass-filled	9.20%	5.87E+00
		injection molding	8.96%	5.72E+00
		market for steel, unalloyed	6.83%	4.36E+00
	Dublin, IE	diecasting aluminum	24.78%	1.58E+01
		steel milling, small parts	12.09%	7.70E+00
		market for nylon 6, glass-filled	9.22%	5.87E+00
		injection molding	8.98%	5.72E+00
		market for steel, unalloyed	6.85%	4.36E+00

Smart Plus	Piscataway, NJ	diecasting aluminum	21.85%	1.55E+01
		market for nylon 6, glass-filled	15.33%	1.09E+01
		steel milling, small parts	10.87%	7.70E+00
		polyurethane production, flexible foam	8.53%	6.04E+00
		injection molding	8.24%	5.83E+00
Smart Conference	Piscataway, NJ	market for aluminum production	17.93%	1.94E+01
		diecasting aluminum	17.17%	1.86E+01
		market for nylon 6, glass filled	13.21%	1.43E+01
		vegetable tanning	11.91%	1.29E+01
		steel milling, small parts	6.98%	7.56E+00

5.5 TOP 5 PROCESS CONTRIBUTING TO WATER DEPLETION

In connection with the Living Product Challenge Impetrative 04 Water Footprint, the table below presents the five processes that make the largest contributions to the cradle-to-gate (as defined by the ILFI) water footprint of the Smart™ chair family. From the results below, it is clear that virgin glass-filled nylon is a top contributor here, too. The production of polyurethane foam for the seat cushion (and seat back of Smart™ Conference) is also as significant contributor. Furthermore, the relative impacts of the top contributors are roughly the same across both assembly locations for the Smart™ chairs, with the exception of vegetable tanning being the top contributor for Smart Conference which is related to the production of the chrome-free leather upholstery used in the product.

Table 17: Top 5 Processes Contributing to Water Consumption ReCiPe 2016 Midpoint (H)

	Final Assembly Location	Process	%	m3
Smart	Piscataway, NJ	market for nylon 6, glass-filled	28.3%	1.92E-01
		polyurethane production, flexible foam	13.88%	9.40E-02
		steel milling, small parts	10.16%	6.88E-02
		diecasting aluminum	9.28%	6.28E-02
		aluminum production	8.57%	5.80E-02
	Dublin, IE	market for nylon 6, glass-filled	28.48%	1.92E-01
		polyurethane production, flexible foam	13.97%	9.40E-02
		steel milling, small parts	10.23%	6.88E-02
		diecasting aluminum	9.34%	6.28E-02
		aluminum production	8.62%	5.80E-02

Smart Ocean	Piscataway, NJ	polyurethane production, flexible foam	16.40%	9.40E-02
		market for nylon 6, glass-filled	15.66%	8.98E-02
		steel milling, small parts	12.01%	6.88E-02
		diecasting aluminum	10.96%	6.28E-02
		aluminum production	10.12%	5.80E-02
	Dublin, IE	polyurethane production, flexible foam	16.54%	9.40E-02
		market for nylon 6, glass-filled	15.80%	8.98E-02
		steel milling, small parts	12.11%	6.88E-02
		diecasting aluminum	11.06%	6.28E-02
		aluminum production	10.21%	5.80E-02
Smart Plus	Piscataway, NJ	market for nylon 6, glass-filled	22.51%	1.66E-01
		polyurethane production, flexible foam	19.60%	1.45E-01
		aluminum production	14.29%	1.05E-01
		steel milling, small parts	9.32%	6.88E-02
		diecasting aluminum	6.41%	4.73E-02
Smart Conference	Piscataway, NJ	vegetable tanning	51.94%	8.14E-01
		market for nylon 6, glass-filled	13.96%	2.19E-01
		polyurethane production, flexible foam	8.28%	1.30E-01
		steel milling, small parts	4.27%	6.69E-02
		diecasting aluminum	3.28%	5.14E-02

5.6 SENSITIVITY ANALYSIS

Table 18: Sensitivity Analysis Results

Factor	BIFMA Life Cycle Stage Name	Model (Piscawatay Facility)	GWP KgCO2eq		% Change
			Original	After Change	
Arm configuration chosen: Fixed arms replacing adjustable arms (only applicable to Smart & Smart Ocean)	Material Acquisition and Pre-processing	Smart	8.95E+01	8.56E+01	4.35%
		Smart Ocean	8.34E+01	7.95E+01	4.67%
Waste generated in assembly facility: eliminating waste sent to landfill	Production (Manufacturing / Assembly)	Smart	8.95E+01	8.93E+01	0.20%
		Smart Ocean	8.34E+01	8.32E+01	0.21%
		Smart Plus	9.10E+01	9.08E+01	0.20%
		Smart Conference	1.35E+02	1.35E+02	0.17%

Allocation method: economic instead of mass allocation	Production (Manufacturing / Assembly)	Smart	8.95E+01	9.01E+01	-0.63%
		Smart Ocean	8.34E+01	8.40E+01	-0.75%
		Smart Plus	9.10E+01	9.23E+01	-1.38%
		Smart Conference	1.35E+02	1.34E+02	0.56%
Shipping Distance: half the mileage. (Original model assumes farthest shipping distance to customer)	Distribution, storage, and use	Smart	8.95E+01	8.30E+01	7.26%
		Smart Ocean	8.34E+01	7.69E+01	7.79%
		Smart Plus	9.10E+01	8.43E+01	7.35%
		Smart Conference	1.35E+02	1.26E+02	6.42%
Chair maintenance: model assumes chair is cleaned half as often	Distribution, storage, and use	Smart	8.95E+01	8.90E+01	0.52%
		Smart Ocean	8.34E+01	8.29E+01	0.55%
		Smart Plus	9.10E+01	9.06E+01	0.51%
		Smart Conference	1.35E+02	1.34E+02	0.34%

6 INTERPRETATION

As shown in Section 5.4, 5.5 and 5.6, the top five processes within the cradle-gate (as defined by the International Living Future Institute) life cycle stages of the Smart chairs, that rank highest in terms of their total contributions to carbon, energy and water consumption, all take place during the Extraction and Pre-Processing life cycle stage.

The extraction and pre-processing of glass-filled nylon, steel milling of small parts (used as a proxy for machining and stamping of steel), and diecasting aluminum rank high in all three impact categories, energy, carbon and water. Chrome-free vegetable tanning of the leather upholstery also ranks high on all three impacts for Humanscale’s newly launched Smart Conference chair. Utilizing more recycled nylon would be effective in reducing the environmental impact of these products in all three impact categories. Additionally, utilizing less leather would have a benefit to the embodied carbon, energy and water footprint of Smart Conference. Primary data on the leather process would strengthen these results and conclusions around this material type.

Diffrient Smart and Smart Ocean come with either fixed or adjustable arms. The models in this report utilize adjustable arms. In the sensitivity analysis, both chairs are modeled with fixed arms to see how much this choice affected the results. On average, modeling the chairs with fixed arms would have reduced the carbon impacts by 4.5% from cradle-grave. Smart Plus is only available with adjustable arms and Smart Conference with fixed arms, so they are not included in this analysis.

In the Sensitivity Analysis, it is assumed that the factory has eliminated sending waste to landfill completely to show how much of an impact reducing waste has to the chair's embodied carbon footprint. The results show only a 0.2% carbon benefit on average.

The models in this report use mass allocation to account for their contribution to the waste, water, and energy inputs during assembly at Humanscale's manufacturing locations. The Sensitivity Analysis shows that the models are not sensitive to the Allocation Method used; mass vs economic. The analysis shows only a 0.8% change to the Global Warming Potential for these chairs.

This report assumes that the task chairs are being shipped to the furthest customer relative to their manufacturing location. In the Sensitivity Analysis, the shipping distance was reduced by 50% which had a significant impact to the Global Warming Potential of the product. The results show an average reduction of 7.2% in the products' cradle to grave carbon footprint when being shipped to a customer half as far.

Limitations of the study include the following:
Availability of primary data for suppliers' energy use, waste generated, and transportation values would have been ideal but was not available. Using primary data could have adjusted the results slightly. Availability of primary data on leather tanning would also strengthen these results.

In general, secondary data was of overall good quality, however the data was of poor geographic coverage and was slightly outdated. This was due to the lack of availability of regionally-specific data and current data in the ecoinvent database. For many inputs, Global averages were used.

7 WORKS CITED

Agribalyse database version v3.0.1, ADEME, (2022)

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U.S. Environmental Protection Agency (2017) Waste Reduction Model (WARM). Available from http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

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Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230. Available at: <http://link.springer.com/10.1007/s11367-016-1087-8> [Accessed 19 16 2020].

APPENDIX B. VERIFICATION DOCUMENTS

LCA VERIFICATION REPORT

Client:
Humanscale

Name of Study:
Smart™ Life Cycle Assessment

Products Included in LCA Report:
Diffrient Smart™, Smart™ Ocean, Smart™ Plus, Smart™ Conference

Review Completed:
September 26, 2023

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CONFORMANCE STATEMENT

In September of 2023, WAP Sustainability Consulting commenced an LCA critical review and verification of the Life Cycle Assessment of the Diffrient Smart™, Smart™ Ocean, Smart™ Plus, Smart™ Conference Chairs. The Life Cycle Assessment (LCA) was commissioned by Humanscale. Stephanie Richardson from Humanscale was the lead LCA practitioner.

The LCA was conducted as a cradle-to-grave assessment with the goal that the LCA would be submitted for Living Product Challenge (LPC) certification and LEED 2.1 MRc point contribution. After several rounds of reviews and modifications, the critical review was finalized in September 26 2023.

The review process was conducted over a couple of weeks and included couple of rounds of comments and responses. WAP Sustainability reviewed the LCA to ISO14040/44 and BIFMA PCR for Seating: UNCPC 3811. In addition to the LCA report, primary data and calculation methods were provided to and reviewed by WAP Sustainability. The LCA model, which was created in OpenLCA, was reviewed as well. All data that was requested by WAP Sustainability was provided in a timely manner.

Critical inputs and assumptions were discussed in depth. Concerns related to these critical assumptions were alleviated through additional information provided by both the manufacture and the LCA practitioner. Additionally, a sensitivity analysis was conducted to compare allocation methods, dataset choices, and shipping and waste assumptions.

The full LCA review checklists are included in the following pages of the report. In summary, the report is a well-written LCA that does not exclude material impacts that would be expected within the life cycle of Humanscale's Diffrient Smart™, Smart™ Ocean, Smart™ Plus, Smart™ Conference Chairs. It is our opinion that the LCA study and LCA report were found to be in compliance with LCA to ISO14040/44. Additionally, the requirements for compliance with ILFI's Living Product Challenge and USGBC LEED 2.1 Material Resources Credits have been met.

W. Brad McAllister
Director
WAP Sustainability Consulting

Manasa Rao
LCA Reviewer
WAP Sustainability Consulting

ISO 14044:2006

	Element	Applicability	Conformance Status	Review Comments (Reviewer Comments in Black. LCA Practitioner Comments in Red)	Approval Date
1	**Review of General Elements of Report**				
1.1	Name of commissioner of study.	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 2.1	9/20/2023
1.2	Name of practitioner of study.	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 2.1	9/20/2023
1.3	Date study was conducted.	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 2.2	9/20/2023
1.4	Does study include a Goal and Scope section?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 2.3 Confirmed appropriate in interviews with practitioner.	9/20/2023
1.5	Does study include an Inventory Analysis section?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 4	9/20/2023
1.6	Does study include an Impact Assessment Section?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 5	9/20/2023
1.7	Does the study include an interpretation of results?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 6	9/20/2023
1.8	Does the study include a discussion on limitations?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 4.2	9/20/2023
1.9	Does the study include a data quality assessment? Are these sufficient to enable goal and scope to be met?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.10	9/20/2023
1.10	Does the study include a statement on ISO compliance?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 2.6	9/20/2023

1.11	Goal clearly defined and consistent with intended application?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 2.3	9/20/2023
1.12	Reason for study stated?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 2.3	9/20/2023
1.13	Intended application stated?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 2.3	9/20/2023
1.14	Function of product system clearly described.	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.1 – one unit of seating to seat one individual, maintained for a 10-year period	9/20/2023
1.15	Functional unit adequately described and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.1 – one unit of seating to seat one individual, maintained for a 10-year period	9/20/2023
1.16	System boundary adequately described and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.3 – Defined in Section 3.3.	9/20/2023
1.18	Are allocation procedures described and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.9 – discussed with practitioner.	9/20/2023
1.18	Geographical coverage stated and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes, some limitations due to data but appropriate based on data availability.	9/20/2023
1.19	Is the cut-off criteria stated and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.8.	9/20/2023
1.20	Are the impact categories described and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 5.1	9/20/2023
1.21	Are the impact assessment and interpretation methods described and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 5.1	9/20/2023
1.22	Source of background data stated and clear?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.10.3	9/20/2023
1.23	Are the data quality requirements of background data described and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.10.3.	9/20/2023

1.24	Source of foreground data stated and clear?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.4, 3.5, 3.10.3	9/20/2023
1.25	Are the data quality requirements of foreground data described and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3 and in supplemental information provided by practitioner.	9/20/2023
1.26	Were assumptions and limitations adequately described?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 4.2 and discussed with practitioner.	9/20/2023
1.27	Did the report include an appropriate statement on critical review?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 2.6	9/20/2023
1.28	Is the report format described (i.e. table of contents, list of figures, etc)?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes	9/20/2023
1.29	Were any additional functions of product system omitted? If so, were the reasons for the omission stated?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	No functions omitted.	9/20/2023
1.30	Did the review find that the justification to be appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	No functions omitted.	9/20/2023
1.31	Were unit processes described adequately?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes, also described during the verification and review process directly with reviewer.	9/20/2023
1.32	Did the reviewer find that the methods used were scientifically and technically valid?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes, technical validity was achieved.	9/20/2023
1.33	If the LCA was comparative in nature, were the product systems of the compared products deemed to be equivalent?	☐ Requirement ☒ Not Applicable	☐ Conformance ☐ Non-Conformance		
1.34	If the LCA was comparative in nature, were the functional units of the compared products deemed to be equivalent?	☐ Requirement ☒ Not Applicable	☐ Conformance ☐ Non-Conformance		
1.35	If the LCA was comparative in nature were the data collection and use choices reasonable to allow for a fair and equivalent comparison?	☐ Requirement ☒ Not Applicable	☐ Conformance ☐ Non-Conformance		

1.36	If the LCA was comparative in nature, were the environmental impact category choices reasonable to allow for a fair and equivalent comparison?	☐ Requirement ☒ Not Applicable	☐ Conformance ☐ Non-Conformance		
2	**Review of General Elements of Report**				
2.1	Are the collection methods used for primary data described and reasonable?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes, throughout the report, supplemental information and discussion with practitioner.	9/20/2023
2.2	Are sources/published literature adequately referenced?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes	9/20/2023
2.3	Is the reference unit of data stated for each input?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes	9/20/2023
2.4	Is the geographical representativeness of data for each input clear?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes, Section 3.10.3.	9/20/2023
2.5	Is the technological representativeness of the data for each input clear?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes, Section 3.10.3. WAP: Since primary data or secondary data through third party datasets was not available for leather, discuss how that affects data quality and what could make technological representativeness better. HS: Added sentence 'Additionally, for cases in which available databases lacked specific inputs and proxies, Humanscale created these inputs using information from available publications. Availability of primary data for would have been ideal but was not available.' to draft attached here. WAP: Ok, closed.	9/25/2023
2.6	Is data relevant and appropriate for the allocation among co-products?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	No co-products.	9/20/2023
2.7	Is the period of data collection clear and appropriate?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – Table 2	9/20/2023

2.8	What time period does the data represent and is it consistent for all inputs? If it is inconsistent across all inputs, is the reason for the inconsistency stated and reasonable?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes - 2022	9/20/2023
2.9	Were any data excluded? If yes, what is the justification of the excluded data. Is the justification adequate and warranted?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes, however within cut-off criteria of below 5% by mass.	9/20/2023
2.10	Is the source of each data input clear?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes, Section 3 and 4.	9/20/2023
2.11	Did the practitioner state data quality requirements? Does all data meet initial stated quality requirements?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes Section 3.10 and discussed.	9/20/2023
2.12	Was the choice of data unbiased so that it did not favor those participating in or financing study?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes, reviewer found that that the choice of data did not bias the study.	9/20/2023
2.13	Were quality assurance and validation procedures used? Does the reviewer consider them to be adequate to meet the goal of the study?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Discussed and found to be appropriate.	9/20/2023
2.14	Were the results of validation methods reviewed by someone other than the LCA practitioner?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Reviewed by reviewers in critical review process.	9/20/2023
2.15	Overall, is data reasonable and appropriate in relation to the goal of the study?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes	9/20/2023
2.16	If allocation was used, was the basis of allocation clear (i.e physical or economical)?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – mass based and checked in sensitivity analysis while comparing with economic allocation.	9/20/2023
2.17	If allocation was used, were the allocation methods described, documented and justified for each unit process in which allocation was made?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes. Section 3.9	9/20/2023
2.18	If allocation was used, were the allocation methods applied in a way that did not bias the study so that it did not favor those participating in or financing study?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes. Section 3.9	9/20/2023
2.20	Was a sensitivity analysis conducted to compare alternative allocation methods?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 5.6. Yes - mass based and checked in sensitivity analysis with economic allocation.	9/20/2023

2.20	If allocation was used, were the allocation methods used consistently across the entire product system? Did the LCA Reviewer find the inconsistencies to be warranted?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – found to be consistent.	9/20/2023
3	Review of Impact Assessment				
3.1	Is there a statement that explains the relative expression of results?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – Section 5.1.	9/20/2023
3.2	Are the chosen impact categories justified and valid?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – Section 5.1.	9/20/2023
3.3	Was the impact assessment carried out in a way that is scientifically and technically valid?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – TRACI and ReCiPe	9/20/2023
3.4	Were methods, such as weighting, used to group or analyze results? If used were the methods described adequately? Additionally, were the methods applied in a way that did not bias the results of the study?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – weighting not used.	9/20/2023
3.5	Does the interpretation include a data quality assessment or a discussion of the data quality assessment?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – Section 6	9/20/2023
3.6	Does the interpretation include a sensitivity analysis or a discussion of a sensitivity analysis that was conducted, if necessary?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – Section 5.6	9/20/2023
3.7	Did the LCA reviewer find that significant findings were discussed adequately.	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – Section 5 and 6	9/20/2023
3.8	Did the LCA reviewer find that the role of excluded elements was evaluated and discussed adequately.	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – Section 3.10.4	9/20/2023
3.9	Did the LCA reviewer find that the study included an adequate discussion of the consistency and reproducibility of the methods applied in the LCA?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – Section 3 and 4.	9/20/2023

3.10	Did the LCA reviewer find that the study included an adequate discussion of the precision, completeness and representativeness of data used in the study?	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Section 3.10	9/20/2023
3.11	Did the LCA reviewer find that the study included an adequate discussion related to the impact of value judgments on the results	☒ Requirement ☐ Not Applicable	☒ Conformance ☐ Non-Conformance	Yes – Section 5.6, sensitivity analysis has been conducted.	9/20/2023

COMPLIANCE TO LIVING PRODUCT CHALLENGE 2.0 LCA-BASED REQUIREMENTS

	Element	Applicability	Conformance Status	Review Comments (Reviewer Comments in Black. LCA Practitioner Comments in Red)	Approval Date
1	**G-04 Life Cycle Assessment General Requirements**				
1.1	All manufacturers must produce and maintain an LCA Model demonstrating the product's cradle-to-grave impacts.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Model collected and reviewed.	9/20/2023
1.2	Performed in accordance with a relevant product category rule (PCR) to ISO 14040/44.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	LCA complies with BIFMA PCR for Seating.	9/20/2023
1.3	Critically reviewed by a third party for conformance with IS0 14044.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Review conducted and passed.	9/20/2023
1.4	Has either been performed by an LCA Certified Practitioner certified by ACLCA (https://aclca.org/lcacp-certification/) or by an ILFI-approved LCA practitioner or consultancy?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Yes, ILFI-approved LCA consultancy.	9/20/2023
1.5	Has either been performed by an LCA Certified Practitioner certified by ACLCA (https://aclca.org/lcacp-certification/) or by an ILFI-approved LCA practitioner or consultancy?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Hotspots identified. 5.3,5.4,5.5	9/20/2023
1.6	The LCA should clearly demonstrate the product's contributions to, at minimum, fossil-based energy, water, and greenhouse gas (GHG) emissions	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	LCA valid for 3 years.	9/20/2023
1.7	LCA models must be valid at the time of certification and for the duration of the 3-Year certification period. If the LCA will expire before recertification, an updated LCA must be resubmitted at the next annual check-in following its expiration.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Any updates in the LCA will be communicated to the reviewer and verified before applying for recertification.	9/20/2023

2	**I04-5 Water Hotspot Identification**				
2.1	A table of process contributions to cradle-to-gate life cycle water consumption, listing at least the top 5 processes ranked in terms of water consumption.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 5.5	9/20/2023
2.2	A brief 1-2 paragraph narrative that interprets the main results and identifies the 5 main drivers of the product's water consumption footprints.	☐ Requirement ☒ Recommendation	☒ Conformance ☐ Non-Conformance	Section 5.5	9/20/2023
3	**I06-6 Energy Hotspot Identification**				
3.1	A table of process contributions to cradle-to-gate life cycle water consumption, listing at least the top 5 processes ranked in terms of energy consumption.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 5.3	9/20/2023
3.2	A brief one- to two-page narrative that interprets the results and identifies the five main drivers of the product's cradle-to-gate fossil energy consumption footprints.	☐ Requirement ☒ Recommendation	☒ Conformance ☐ Non-Conformance	Section 5.3	9/20/2023
4	**I14-4 Carbon Hotspot Identification**				
4.1	A table of process contributions to cradle-to-gate life cycle water consumption, listing at least the top 5 processes ranked in terms of GHG emissions.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 5.4	9/20/2023
4.2	A brief narrative that interprets the results and identifies the 5 main drivers of the product's cradle-to-gate carbon Footprints, and their relevance.	☐ Requirement ☒ Recommendation	☒ Conformance ☐ Non-Conformance	Section 5.4	9/20/2023

COMPLIANCE TO LEED V4.1 LCA-BASED REQUIREMENTS

	Element	Applicability	Conformance Status	Review Comments (Reviewer Comments in Black. LCA Practitioner Comments in Red)	Approval Date
1	BPDO - Environmental Product Declaration – Public Life Cycle Assessment Option (1 pt.)				
1.1	Publicly Available	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	https://www.humanscale.com/resources/designer-toolkit/green-design.cfm	9/20/2023
1.2	Critically Reviewed	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Yes.	9/20/2023
1.3	ISO14044 Compliant	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Critical review confirmed conformance.	9/20/2023
1.4	At Least Cradle to Gate in Scope	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Yes, cradle to grave in scope.	9/20/2023
1.5	Cover or Summary Sheet that includes: -All requirements outlined in LEED v4 reference guide for this section -The type of LCA software used to conduct the assessment; -Date of assessment with period of validity or expiration date of life cycle assessment, -URL link to the publicly available version of the document.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Yes, pages 2 and 3 of the document.	9/20/2023

BIFMA PCR FOR SEATING: UNCPC 3811 VERSION 3

	Element	Applicability	Conformance Status	Review Comments (Reviewer Comments in Black. LCA Practitioner Comments in Red)	Approval Date
1	**Goal and Scope Requirements for the LCA study**				
1.1	Is the scope cradle-to-grave?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.3	9/20/2023
1.2	Does product description include name of manufacturer, model number, general description, and a picture?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.2.1	9/20/2023
1.3	Functional unit equals one unit of seating to seat one individual, for a period of 10 years? (note: results shall not be normalized from a fraction of a chair)	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.1	9/20/2023
1.4	Do products designed for 10 or more years use only 1 unit for ref flow (1 unit for 10 years max)?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.1. Yes.	9/20/2023
1.5	Do products that have warranty periods and/or designed for less than 10 yrs report the necessary number of units for the 10 yr period?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.1. No.	9/20/2023
1.6	If product meets ANSI/BIFMA X5.1, is the service life given as 10 yrs?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Table 1. Yes.	9/20/2023
1.7	If product does not meet ANSI/BIFMA X5.1, and the warranty period is: - 5 years or more, is the product service life given as 5 years - less than 5 years, is service life equal to warranty period?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Not applicable since product meets ANSI/ BIFMA X5.1.	9/20/2023

1.6	Are all known flows that are knowingly omitted, justified? All known energy flows greater than 1% shall be included. Cumulative mass and energy omissions shall not exceed 5%	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.8 and confirmed in background data and LCA practitioner interviews.	9/20/2023
2	**System Boundaries**				
2.1	Does the LCA report detail the system boundaries, including a description of LC stages for the product?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Figure 2 and throughout the document.	9/20/2023
2.3	Is transportation of materials included in LC impact assessment? This includes transport between stages and within the manufacturing stage between facilities owned by the company.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Table 2 and LCA practitioner interviews	9/20/2023
3	**UpsSmartm Stage**				
3.1	Are primary data used for upsSmartm processes, if available? If not, secondary data may be used.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Ecoinvent secondary data primarily used for upstream data.	9/20/2023
3.2	If using a dataset for upsSmartm without transport embedded, are trans distances consistent with those given in Table 1 of PCR? (NA -based)	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	For the most part, transportation distances embedded.	9/20/2023
4	**Production Stage/EOL stages**				
4.1	Are primary data used, where available, for production processes under control of mfr?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	From primary data review and LCA practitioner interview. For the most part primary data was used where available. When not available, secondary datasets or literature review was applied.	9/20/2023
4.2	Absent primary data, is the trans distance used for process waste recycling/recovery/disposal processes 20 miles (32 km)) within NA?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.5 and confirmed in primary data provided during review.	9/20/2023
4.3	If primary data are not used for EOL, is the distribution of materials at EOL aligned with an approved guidance (see PCR)? Are Non recycled materials must be modeled as 80% landfilled/20% incineration?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.7 and confirmed in LCA model review.	9/20/2023
5	**Allocation and Units**				

5.1	When allocation cannot be avoided, does allocation follow either mass (or other biophysical relationship) or economic allocation methods? If not, are deviations justified?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.9	9/20/2023
5.2	For allocation due to recycling, the recycled content method shall be used. If not, are deviations justified?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 3.9 and confirmed by model review.	9/20/2023
5.3	Are units given in SI units with no more than 3 significant digits?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Yes.	9/20/2023
6	**Calculation Rules and Data Requirements**				
6.1	For facilities under the control of the manufacturer, are primary data used? If multiple locations mfr the components, a single source can be used as representative data, or an average, may be used for operations contributing less than 10% of the total prod output.	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Review of primary data and LCA model.	9/20/2023
6.2	For the US, are energy data aligned with region of mfr? Out of the US, is a reasonable and justified source used?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Review of primary data and LCA model. Sources mentioned in Table 5.	9/20/2023
6.3	Are primary data used for unit processes that contribute to the majority of mass and energy flows, or which have the most relevant env emissions?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Yes, primary data has been used when available. Otherwise, third-party verified secondary datasets (ecoinvent), or data from published literature has been used.	9/20/2023
6.4	Is a data quality assessment conforming to ISO 14044 presented?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	See 14044 checklist.	9/20/2023
6.5	Are data obtained from the manufacturer considered average monthly data for the year of study?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Yes. Review of primary data and LCA model.	9/20/2023
6.6	Is documentation given for all individual data sources?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Table 5	9/20/2023
6.7	Are primary energy data or appropriate regional secondary energy sources used? If not, does the source of energy data comply with guidance given in the PCR?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Table 5	9/20/2023

6.8	Are carbon offsets excluded from the inventory?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Yes, no carbon offsets utilized.	9/20/2023
6.9	Do the LCA Impacts include each of the following in TRACI 2.1: Global Warming Potential Acidification Ozone Creations (POCP) Eutrophication Ozone Depletion	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	Section 5.1	9/20/2023
6.10	Are life cycle impacts reported per life cycle stage and in total?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	See Section 5.	9/20/2023
6.11	Has a sensitivity analysis been performed confirming that an appropriate model was used?	☒ Requirement ☐ Recommendation	☒ Conformance ☐ Non-Conformance	See section 5.6	9/20/2023

LCA MODEL REVIEW CHECKLIST

	Plan Hierarchy	Process Name	Appropriate Inputs/outputs	Connection Check	Mass Balance Check	Datasets Appropriate	Notes
	Name of final plan: Smart_ecoinvent_38_cutoff_regio_3011_with_methods.zolca						
1	Smart Ocean	Smart Ocean Cradle Gate (Dub)	Confirmed	Confirmed	Confirmed	Confirmed	
2		Smart Ocean Cradle Grave (Dub)	Confirmed	Confirmed	Confirmed	Confirmed	
3		Smart Ocean Trspt to HS (Dub)	Confirmed	Confirmed	Confirmed	Confirmed	
4		Smart Ocean Cradle Gate (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
5		Smart Ocean Cradle Grave (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
6		Smart Ocean Trspt to HS (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
7		Smart Ocean Cradle Gate (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
8		Smart Ocean Cradle Grave (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
9		Smart Ocean Trspt to HS (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
10		Smart Ocean MatExtract	Confirmed	Confirmed	Confirmed	Confirmed	
11	Smart Conference	Tanning	Confirmed	Confirmed	Confirmed	Confirmed	WAP: Inputs and outputs were blank in the version of the model I have. HS: Added a table in the report to describe inputs. WAP: Closed.
12		Tanning process - pre-soaking	Confirmed	Confirmed	Confirmed	Confirmed	WAP: Inputs and outputs were blank in the version of the model I have. HS: Added a table in the report to describe inputs. WAP: Closed.

13		Smart Conference MatExtract (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	WAP: Did not see any leather input here as well. HS: Leather input was only available in the Agribalyse Database, so I ran the model for cow hide in the database and added it to the rest of the LCA results in excel. WAP: Ok, closed.
14	Smart Plus	Smart Plus Cradle Gate (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
15		Smart Plus Cradle Grave (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
16		Smart Plus Trspt to Cust (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
17		Smart Plus Trspt to HS (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
18		Smart Plus Cradle Gate (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
19		Smart Plus Cradle Grave (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
20		Smart Plus EOL Disposal	Confirmed	Confirmed	Confirmed	Confirmed	
21		Smart Plus EOL Trspt	Confirmed	Confirmed	Confirmed	Confirmed	
22		Smart Plus MatExtract	Confirmed	Confirmed	Confirmed	Confirmed	
23		Smart Plus MatTrans	Confirmed	Confirmed	Confirmed	Confirmed	
24		Smart Plus Trsp to HS (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
25		Smart Plus Trspt to Cust (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
26	Smart Task	Smart Task Cradle Grave (Dub)	Confirmed	Confirmed	Confirmed	Confirmed	
27		Smart Task Gate (Dub)	Confirmed	Confirmed	Confirmed	Confirmed	
28		Smart Task Trspt to Cust (Dub)	Confirmed	Confirmed	Confirmed	Confirmed	
29		Smart Task Trspt to HS (Dub)	Confirmed	Confirmed	Confirmed	Confirmed	
30		Smart Task Cradle Gate (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
31		Smart Task Cradle Grave (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
32		Smart Task Trspt to Cust (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	

33		Smart Task Trspt to HS (Fres)	Confirmed	Confirmed	Confirmed	Confirmed	
34		Smart Task Cradle Gate (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
35		Smart Task Cradle Grave (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
36		Smart Task EOL Disposal	Confirmed	Confirmed	Confirmed	Confirmed	
37		Smart Task EOL Trspt	Confirmed	Confirmed	Confirmed	Confirmed	
38		Smart Task MatExtract	Confirmed	Confirmed	Confirmed	Confirmed	
39		Smart Task MatTrans	Confirmed	Confirmed	Confirmed	Confirmed	
40		Smart Task Trspt to Cust (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
41		Smart Task Trspt to HS (Pisc)	Confirmed	Confirmed	Confirmed	Confirmed	
42	All Smart Chairs	Assembly (Dub) 2022	Confirmed	Confirmed	Confirmed	Confirmed	
43	All Smart Chairs	Assembly (Fres) 2022	Confirmed	Confirmed	Confirmed	Confirmed	
44	All Smart Chairs	Assembly (Pisc) 2022	Confirmed	Confirmed	Confirmed	Confirmed	
45	All Smart Chairs	Chair Maintenance	Confirmed	Confirmed	Confirmed	Confirmed	