M2.1 / M8.1 / M10 Monitor Arms

Life Cycle Assessment

Study Completed: January - July, 2020
Critical Review Completed: September, 2020
Critical Review Completed By: WAP Sustainability

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M2.1	M8.1	M10
Standard Single or Dual Monitors 5-15.5 lbs.	Heavy Single or Dual Monitors 6-28 lbs.	Up to three monitors and & large TV formats 20-48 lbs.
		

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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 Coordinator; 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.

There is no applicable BIFMA PCR available for monitor arms. As such, this LCA does not follow a specific PCR but was set up to follow the general format of available BIFMA PCRs as closely as possible.

2.2 REPORTING DATE

The LCA study was commenced in June 2019 and a draft was submitted for critical review to WAP Sustainability in August 2020. The final approval of the document took place on September 21, 2020.

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 monitor arm products, 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.
- 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

There is no applicable BIFMA PCR available for monitor arms. As such, this LCA does not follow a specific PCR but was set up to follow the general format of available BIFMA PCRs as closely as possible.

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 support one monitor. Does not include monitor.

The functional unit for this LCA study shall be one unit of monitor arm to support one monitor, maintained for a 10-year period. The warranty for M2.1 and M8.1 is 15 years and is 10 years for M10. Each of these are expected to perform at least as long as its warranty period as such, replacement parts are not required within this 10-year timeframe.

3.2 PRODUCT DESCRIPTION

3.2.1 Product Description and Specifications

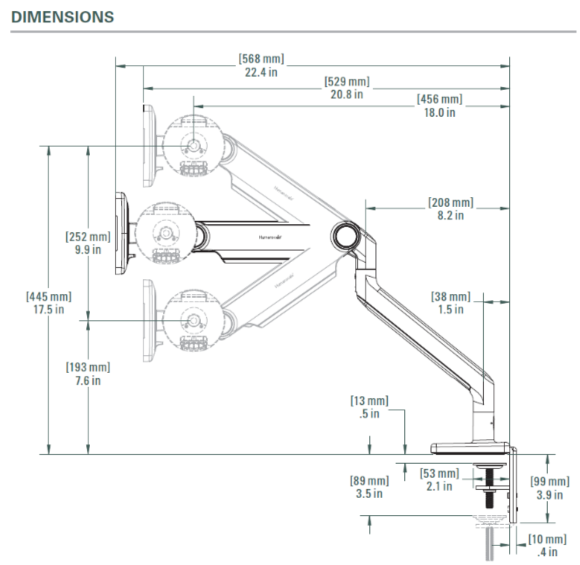
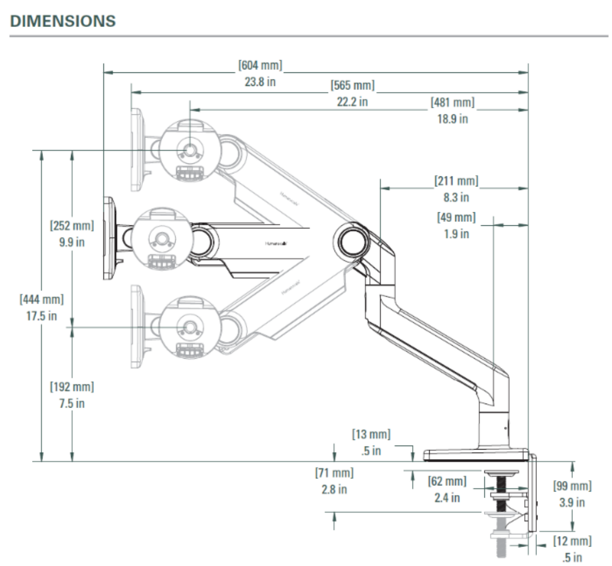
Humanscale's next generation monitor arm line instantly personalizes any workstation for improved comfort, health and productivity. Designed for unprecedented adaptability, our monitor arms focus on ergonomics and the use of technology, while featuring ultra-sleek aesthetics. M2.1 supports a better working posture, creates more usable desktop space and helps maintain a clutter-free environment. It offers quick, simple installation and industry-leading flexibility thanks to patent-pending Quick Release joints that instantly snap together for a secure and robust fit. Fully compatible with traditional desks and sit/stand workstations alike, M2.1 meets a variety of configuration needs for lighter monitors up to 15.5 lbs. M8.1 meets a variety of configuration needs for single monitors from 6 to 28 pounds or – with an optional crossbar support – dual monitors up to 12 pounds each. Built to hold heavier equipment, a strong triple crossbar allows M10 to hold up to three monitors or 48 pounds – all while maintaining a simple and sleek design.

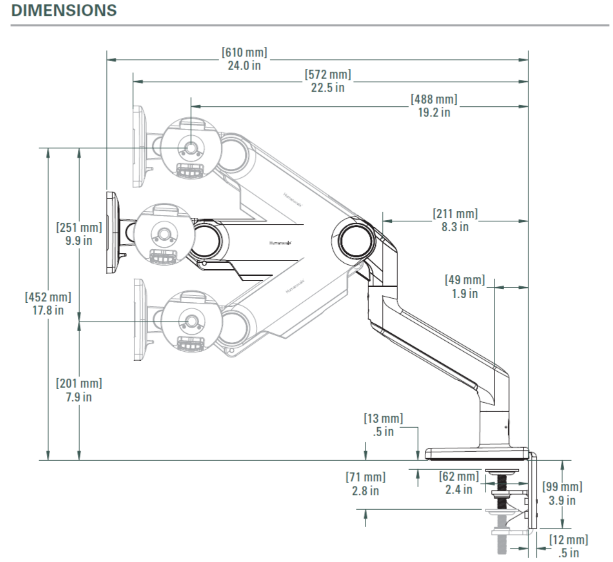
Featuring innovations like Humanscale's patented Weight-Compensating Spring Technology and Smart Stop functionality, M2.1, M8.1 and M10 enable the personalization and flexibility needed for today's evolving workplaces.

Model numbers for M2.1 begin with 'M21CM', for M8.1 begin with 'M81CM', for M10 begin with 'M10CM'.

All three models in this LCA have the following features; arm style: angled link/ dynamic link, two-piece clamp mount base, color: silver with gray trim. Although each of these models can hold more than one monitor, configurations meant to hold one monitor were chosen for consistency per the functional unit.

Table 1: Product Specifications

Monitor Weight Capacity	Standard Single or Dual Monitors 5-15.5 lbs  **M2.1**	
	Single 6-28 lbs  **M8.1**	

	Heavy Single up to 20-40 lbs  **M10**	
Height Adjustment	M2.1: 6.7" - 17.1" M8.1: 7.6" - 17.7" M10: 7.6" - 17.7"	
Product Weight	M2.1: 5.9 lbs (2.7kg) M8.1: 11 lbs (5.0kg) M10: 11.5 lbs (5.2kg)	

3.2.2 Technical Data

Table 2: Technical Details	
Sustainability certification	Declare: HSC-0037, HSC-0041, HSC-0043
	ANSI/BIFMA LEVEL® 3: SCS-SCF-05105
	HPD Label
VOC emission	Indoor Advantage Gold: SCS-IAQ-02892
UL 1286	Certification #: 20180918-E494239, 20190305-E494239

3.3 SYSTEM BOUNDARY

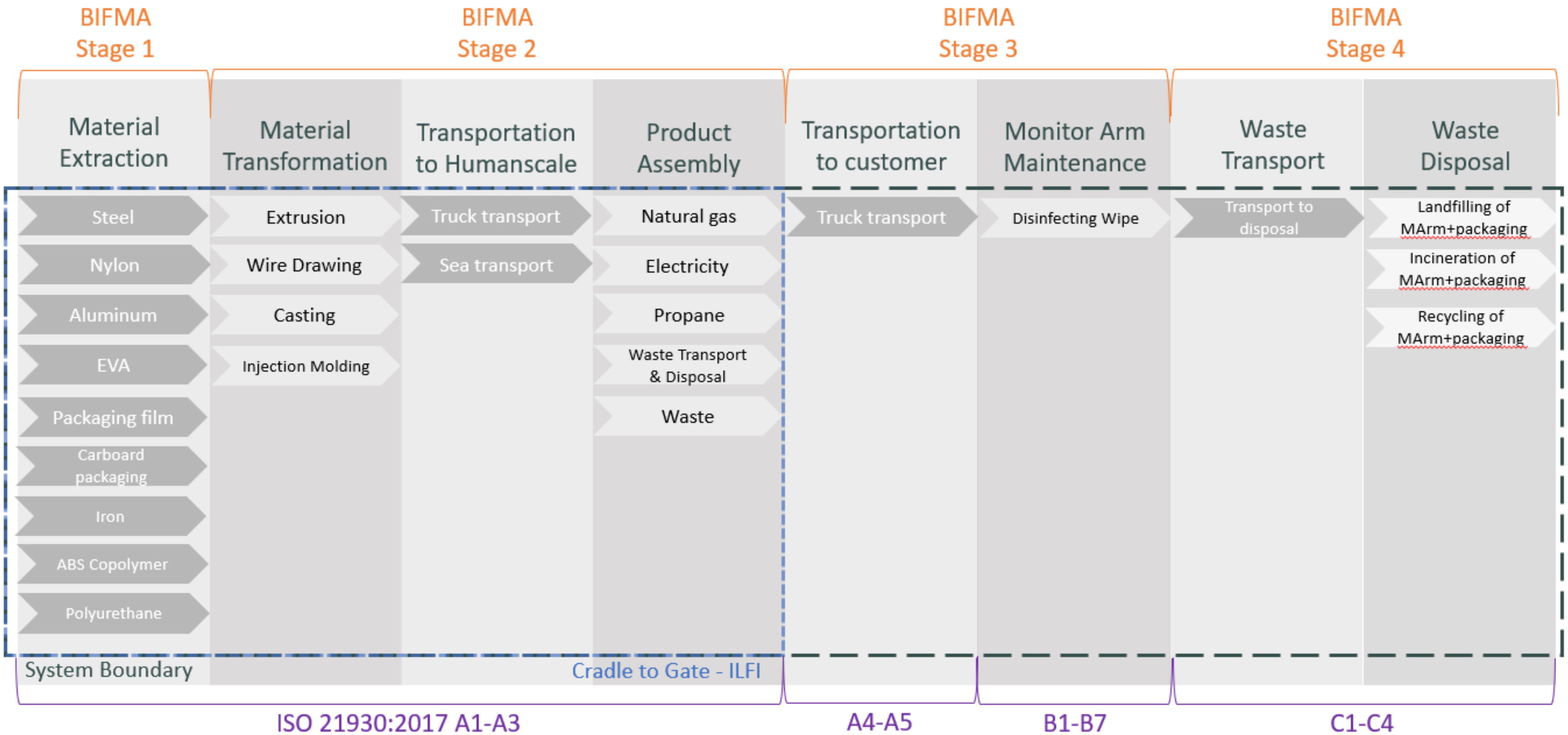
For full cradle-to-grave analysis, the upstream system boundary includes the full cradle-to-gate supply chains of all inputs beginning with material extraction and ending with final assembly of the product by Humanscale. The downstream system boundary begins with shipping of the product to the customer 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 3: Summary of Included Life Cycle Stages			
Module Name	BIFMA Life Cycle Stage Name	Analysis Period	Summary of Included Elements
M2.1 MatExtract	**Material Acquisition and Pre-processing**	2019	Raw material extraction, transportation and refining including packaging as defined by secondary data.
M2.1 MatTrans	**Production (Manufacturing / Assembly)**	2019	Manufacturing of components.
M2.1 Trspt to HS	**Production (Manufacturing / Assembly)**	2019	Transportation of product components to Humanscale. Primary data is used.
Assembly	**Production (Manufacturing / Assembly)**	2019	Final assembly and packing at Humanscale facility. Primary data is used for electricity, natural gas and waste.
M2.1 Trspt to Cust	**Distribution, storage, and use**	2019	Transportation to customer. Farthest shipping distance via frieght truck is assumed.
Monitor Arm Maintenance	**Distribution, storage, and use**	2019	Cleaning of product.
M2.1 EOL Trspt	**End of life**	2019	Transportation of product and product packaging to disposal facility.
M2.1 EOL Disposal	**End of Life**	2019	Landfilling and incernerating of packaging and product parts.

Figure 1: 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, water, inbound transport, and waste, outbound transportation to customer, use phase, and end of life including transportation and treatment of waste.

Figure 1: 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 4: Material Composition (grams)			
	M2.1	M8.1	M10
Plastic	180.1	195.25	204.2
Aluminum	1,298	2,560.13	2,437.85
Steel	1,657.24	1,861.46	1,847.55
Cast Iron	0	55.04	51.2
Packaging	754	1,834.37	1,834.37
Other / Omitted	71.39	175.49	111.13
Total Weight	3,960.73	6,681.74	6,486.30

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

No additional preparation of the final product, including forming, surface treatment, machining and/or other processes occurs.

In this phase, primary data for waste material transportation was calculated using the 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.

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 monitor arm use/maintenance.

- Transportation from manufacturing gate to customer
- Product maintenance (cleaning with disinfecting wipe once monthly)

Except in rare cases, the product is shipped direct to customer. As such, storage is not relevant. Additionally, 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.

Transportation mode and distances in this phase was 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.

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 EPA Recycling Rates for North America. Collection of end of life product and packaging distances are based on the current USEPA WARM Model. All waste materials are assumed to be disposed of in the 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 5: End of Life Management						
Product	Material Type	Weight (grams)	Recycling Rate*	Weight Recycled (grams)	Weight Incinerated (grams)**	Weight Landfilled (grams)**
M2.1	Plastic	200.10	8.37%	16.75	146.68	36.67
	Paperboard	734.00	65.92%	483.82	200.14	50.04

	Aluminum	1,298.00	16.19%	210.12	870.30	217.58
	Ferrous metals	1,657.24	32.66%	541.30	892.75	223.19
M8.1	Plastic	215.25	8.37%	18.01	157.79	39.45
	Paperboard	1,814.37	65.92%	1,195.95	494.73	123.68
	Aluminum	2,560.13	16.19%	414.43	1,716.56	429.14
	Ferrous metals	1,916.50	32.66%	625.98	1,032.41	258.10
M10	Plastic	224.2	8.37%	18.76	164.35	41.09
	Paperboard	1,814.37	65.92%	1,195.95	494.73	123.68
	Aluminum	2,437.85	16.19%	394.64	1,634.57	408.64
	Ferrous metals	1,898.75	32.66%	620.19	1,022.85	255.71

*Recycling rates from the 2017 EPA Sustainable Materials Management (SMM) – Materials and Waste Management in the United States Key Facts and Figures.
** 80% of the material not recycled should be modeled using landfill and 20% using incineration.

3.8 CUT-OFF CRITERIA

This LCA follows typical cut-off criteria requirements, 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 all Acetal POM components because the Ecoinvent database does not have this input material nor could we find one that was close enough for use as a substitute. The Acetal POM that was omitted was 6.4 grams for M2.1 (0.16%), 8.44 grams for M8.1 (0.12%) and 12.0 grams for M10 (0.18%)
- The system model also omits Acrylic (PMMA) and powder coating, zinc and painting totaling 64.99 grams for M2.1 (1.6%), 167.05 grams for M8.1 (2.5%), and 99.13 grams for M20 (1.53%).
- In total, the system model omits less than 2.6% of each products' total 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 monitor arm was divided by the total weight of all products produced in the Humanscale facility during the 2019 calendar year to proportionately allocate waste and energy. For background processes we used the Ecoinvent database, version 3.6 APOS, which implements an attributional modeling approach; "APOS" refers to "allocation at the point of substitution."

3.10 DATA QUALITY REQUIREMENTS

3.10.1 Geographical Coverage

Final manufacturing of the product occurs in two Humanscale facilities in North America & Europe, and the product is shipped to customers globally. For the purpose of this report, six LCA models have been created to represent the impacts of the monitor arms specific to its final assembly location and their supply chains. The model accounts for applicable interfacility transportation.

Unites 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, 2019.

3.10.3 Technical Coverage

Primary data was retrieved from Humanscale utility and waste hauling bills from the most current complete calendar year (2019), 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 3.6.

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 6 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. No flows were knowingly excluded from the study.

Table 6: Secondary Dataset Reference

Dataset	Source	Time Coverage	Geographical Coverage	Technical Coverage	Overall Representativeness
market for acrylonitrile-butadiene-styrene copolymer	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Great, appropriate technology but not exact geography
market for aluminium, cast alloy	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Great, appropriate technology but not exact geography
market for nylon 6	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Great, appropriate technology but not exact geography
packaging film, low density polyethylene	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Great, appropriate technology but not exact geography
market for polyurethane, flexible foam	Ecoinvent	Within 5-year period	GLO	Used as proxy for TPU	Good, closest technology, not exact geography
market for steel, unalloyed	Ecoinvent	Within 5-year period	ROW	Appropriate technology	Great, appropriate technology but not exact geography
corrugated board box	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography

market for cast iron	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Great, appropriate technology but not exact geography
market for ethylene vinyl acetate copolymer	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
market for impact extrusion of aluminum	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Great, appropriate technology but not exact geography
market for impact extrusion of steel	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Great, appropriate technology but not exact geography
market for injection moulding	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Great, appropriate technology but not exact geography
market for wire drawing, steel	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Great, appropriate technology but not exact geography
transport, freight, lorry 16-32 metric ton, EURO4	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Excellent
transport, freight, sea, transoceanic tanker	Ecoinvent	Within 5-year period	GLO	Appropriate technology	Excellent
market for electricity, low voltage	Ecoinvent	Within 5-year period	Ireland	Appropriate technology	Excellent
market for electricity, low voltage	Ecoinvent	Within 10-year period	RFC	Appropriate technology	Excellent
municipal solid waste	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Good, appropriate technology but not exact geography
municipal waste collection service by 21 metric ton lorry	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
market for natural gas, low pressure	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
natural gas production, propane	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
soap	Ecoinvent	Within 5-year period	RoW	Used as proxy for cleaner in disinfecting wipe	Good, closest technology, not exact geography
market for tap water	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
market for textile, non woven polyester	Ecoinvent	Within 5-year period	RoW	Used as proxy for wipe	Good, closest technology, not exact geography
market for polyethylene terephthalate, granulate, bottle grade	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
treatment of scrap aluminium, municipal incineration	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
treatment of waste aluminium, sanitary landfill	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography

treatment of waste paperboard, municipal incineration	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
treatment of waste paperboard, sanitary landfill	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
treatment of scrap steel paperboard, municipal incineration	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography
treatment of scrap steel paperboard, sanitary landfill	Ecoinvent	Within 5-year period	RoW	Appropriate technology	Great, appropriate technology but not exact geography

3.10.4 Treatment of Missing Data

We leave upstream supply chain electricity modeling (embedded within the background database) unaltered. 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 clean their monitor arm in in accordance with Humanscale's Cleaning Instructions for Humanscale Monitor Arm Products. All Humanscale products come with Disassembly Instructions and are highly recyclable, however the model assumes the product is landfilled, incinerated and recycled based on the current USEPA WARM Model.

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 Searoutes.com. 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.

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. Although there is no BIFMA PCR for this product category, the LCA uses TRACI 2.1 based on the requirements of other PCRs BIFMA has published. 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 7: Impact Parameters

Required By	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 monitor arm to provide support to one monitor.

5.2.1 M2.1

Table 8: M2.1 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)	2.90E-02	2.90E-02	1.54E-02	1.65E-03	7.50E-02
	EP (kg N eq)	2.34E-02	2.11E-02	7.43E-03	4.25E-03	5.62E-02
	GWP (kg CO2 eq)	7.35E+00	5.96E+00	3.72E+00	6.29E-01	1.77E+01
	OD (kg CFC 11 eq)	5.55E-07	9.21E-07	6.50E-07	6.02E-08	2.19E-06
	Smog (kg O3 eq)	3.56E-01	4.80E-01	3.04E-01	3.31E-02	1.17E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	7.35E-02	3.38E-02	2.91E-02	3.27E-03	1.40E-01
	FS (kg oil-Eq)	1.74E+00	1.73E+00	1.42E+00	8.43E-02	4.98E+00

Table 9: M2.1 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)	2.90E-02	2.19E-02	1.57E-02	1.65E-03	6.83E-02
	EP (kg N eq)	2.34E-02	1.75E-02	7.52E-03	4.25E-03	5.26E-02
	GWP (kg CO2 eq)	7.35E+00	3.62E+00	3.80E+00	6.29E-01	1.54E+01
	OD (kg CFC 11 eq)	5.55E-07	3.61E-07	6.69E-07	6.02E-08	1.65E-06
	Smog (kg O3 eq)	3.56E-01	2.99E-01	3.12E-01	3.31E-02	9.99E-01
ReCiPe 2016 Midpoint (H)	WC (m3)	7.35E-02	2.89E-02	2.93E-02	3.27E-03	1.35E-01
	FS (kg oil-Eq)	1.74E+00	9.16E-01	1.44E+00	8.43E-02	4.18E+00

5.2.2 M8.1

Table 10: M8.1 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)	2.72E-02	5.85E-02	2.23E-02	2.90E-03	1.11E-01
	EP (kg N eq)	2.51E-02	4.81E-02	9.29E-03	7.16E-03	8.96E-02
	GWP (kg CO2 eq)	7.83E+00	1.27E+01	5.34E+00	1.20E+00	2.71E+01
	OD (kg CFC 11 eq)	4.38E-07	1.73E-06	1.03E-06	1.01E-07	3.29E-06
	Smog (kg O3 eq)	3.48E-01	9.16E-01	4.67E-01	5.65E-02	1.79E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	7.38E-02	8.15E-02	3.20E-02	5.79E-03	1.93E-01
	FS (kg oil-Eq)	1.92E+00	3.65E+00	1.97E+00	1.45E-01	7.69E+00

Table 11: M8.1 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)	2.72E-02	4.74E-02	2.29E-02	2.90E-03	1.00E-01
	EP (kg N eq)	2.51E-02	4.24E-02	9.44E-03	7.16E-03	8.41E-02
	GWP (kg CO2 eq)	7.83E+00	9.22E+00	5.47E+00	1.20E+00	2.37E+01
	OD (kg CFC 11 eq)	4.38E-07	8.81E-07	1.06E-06	1.01E-07	2.48E-06
	Smog (kg O3 eq)	3.48E-01	6.36E-01	4.80E-01	5.65E-02	1.52E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	7.38E-02	7.41E-02	3.22E-02	5.79E-03	1.86E-01
	FS (kg oil-Eq)	1.92E+00	2.41E+00	2.02E+00	1.45E-01	6.50E+00

5.2.3 M10

Table 12: M10 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)	2.69E-02	5.69E-02	2.20E-02	2.81E-03	1.09E-01
	EP (kg N eq)	2.48E-02	4.67E-02	9.20E-03	7.18E-03	8.78E-02
	GWP (kg CO2 eq)	7.80E+00	1.24E+01	5.26E+00	1.19E+00	2.66E+01
	OD (kg CFC 11 eq)	4.32E-07	1.68E-06	1.01E-06	9.81E-08	3.22E-06
	Smog (kg O3 eq)	3.44E-01	8.90E-01	4.59E-01	5.52E-02	1.75E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	7.29E-02	7.82E-02	3.19E-02	5.58E-03	1.89E-01
	FS (kg oil-Eq)	1.94E+00	3.55E+00	1.94E+00	1.41E-01	7.57E+00

Table 13: M10 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)	2.69E-02	4.61E-02	2.25E-02	2.81E-03	9.83E-02
	EP (kg N eq)	2.48E-02	4.12E-02	9.35E-03	7.18E-03	8.24E-02
	GWP (kg CO2 eq)	7.80E+00	8.95E+00	5.39E+00	1.19E+00	2.33E+01
	OD (kg CFC 11 eq)	4.32E-07	8.57E-07	1.04E-06	9.81E-08	2.43E-06
	Smog (kg O3 eq)	3.44E-01	6.18E-01	4.72E-01	5.52E-02	1.49E+00
ReCiPe 2016 Midpoint (H)	WC (m3)	1.94E+00	2.34E+00	1.99E+00	1.41E-01	6.41E+00
	FS (kg oil-Eq)	7.29E-02	7.09E-02	3.21E-02	5.58E-03	1.81E-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 M2.1, M8.1 and M10. From the results below, it is clear that the top contributors to the energy footprint of the products are related to raw material sourcing. Specifically, steel used in the arms' base clamp and vesa, and aluminum for the arm and base are significant contributors. Furthermore, the relative impacts of the top contributors are roughly the same across both final assembly locations for all three monitor arms, however, overall impacts are slightly less for the products manufactured in Dublin due to shorter transportation distances.

Table 14: Top 5 Processes Contributing to Energy Consumption
ReCiPe 2016 Midpoint (H)

	Final Assembly Location	Process	%	Kg oil-Eq
M2.1	Piscataway, NJ	transport, freight, lorry 16-32 metric ton	23.47%	8.16E-01
		market for steel, unalloyed	17.44%	6.06E-01
		market for aluminium, cast alloy	16.83%	5.85E-01
		market for acrylonitrile-butadiene-styrene copolymer	10.67%	3.71E-01
		market for impact extrusion of steel	8.86%	3.08E-01
	Dublin, IE	market for steel, unalloyed	22.82%	6.06E-01
		market for aluminium, cast alloy	22.01%	5.85E-01
		market for acrylonitrile-butadiene-styrene copolymer	13.95%	3.71E-01
		market for impact extrusion of steel	11.59%	3.08E-01
		market for impact extrusion of aluminium	11.43%	3.04E-01
M8.1	Piscataway, NJ	transport, freight, lorry 16-32 metric ton	23.86%	1.33E+00
		market for steel, unalloyed	13.59%	7.58E-01
		market for casting, steel	12.65%	7.05E-01
		market for impact extrusion of aluminium,	12.59%	7.02E-01
		market for acrylonitrile-butadiene-styrene copolymer	10.11%	5.64E-01
	Dublin, IE	market for steel, unalloyed	26.51%	4.52E+00
		market for impact extrusion of aluminium,	17.24%	2.94E+00
		market for casting, steel, lost-wax	15.09%	2.57E+00
		market for impact extrusion of steel,	10.88%	1.86E+00
		market for acrylonitrile-butadiene-styrene copolymer	7.15%	1.22E+00
M10	Piscataway, NJ	transport, freight, lorry 16-32 metric ton	23.57%	1.29E+00
		market for steel, unalloyed	13.63%	7.48E-01
		market for impact extrusion of aluminium	12.18%	6.68E-01
		market for casting, steel	12.16%	6.67E-01
		market for acrylonitrile-butadiene-styrene copolymer	11.44%	6.28E-01
	Dublin, IE	market for steel, unalloyed	17.46%	7.48E-01
		market for impact extrusion of aluminium,	15.60%	6.68E-01
		market for casting, steel	15.58%	6.67E-01
		market for acrylonitrile-butadiene-styrene copolymer	14.65%	6.28E-01
		market for impact extrusion of steel	10.18%	4.36E-01

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 M2.1, M8.1 and M10. From the results below, it is clear that the top contributors to the energy footprint of the products are related to raw material sourcing. Specifically, steel used in the arms' base clamp and vesa, and aluminum for the arm and base are significant contributors. Furthermore, the relative impacts of the top contributors are roughly the same across both final assembly locations for all three monitor arms, however, overall impacts are slightly less for the products manufactured in Dublin due to shorter transportation distances.

Table 15: Top 5 Processes Contributing to Carbon Footprint
TRACI 2.1

	Final Assembly Location	Process	%	Kg CO2-Eq
M2.1	Piscataway, NJ	market for steel, unalloyed	27.18%	3.62E+00
		market for aluminium, cast alloy	18.00%	2.39E+00
		transport, freight, lorry 16-32 metric ton	17.95%	2.39E+00
		market for impact extrusion of steel	10.08%	1.34E+00
		market for impact extrusion of aluminium	9.56%	1.27E+00
	Dublin, IE	market for steel, unalloyed	32.97%	3.62E+00
		market for aluminium, cast alloy	21.83%	2.39E+00
		market for impact extrusion of steel, cold,	12.23%	1.34E+00
		market for impact extrusion of aluminium	11.60%	1.27E+00
		market for acrylonitrile-butadiene-styrene copolymer	7.31%	8.02E-01
M8.1	Piscataway, NJ	market for steel, unalloyed	21.97%	4.52E+00
		transport, freight, lorry 16-32 metric ton	18.93%	3.90E+00
		market for impact extrusion of aluminium	14.28%	2.94E+00
		market for casting, steel	12.50%	2.57E+00
		market for impact extrusion of steel,	9.01%	1.86E+00
	Dublin, IE	market for steel, unalloyed	26.51%	4.52E+00
		market for impact extrusion of aluminium,	17.24%	2.94E+00
		market for casting, steel	15.09%	2.57E+00
		market for impact extrusion of steel	10.88%	1.86E+00
		market for acrylonitrile-butadiene-styrene copolymer	7.15%	1.22E+00
M10	Piscataway, NJ	market for steel, unalloyed	22.12%	4.46E+00
		transport, freight, lorry 16-32 metric ton,	18.77%	3.79E+00
		market for impact extrusion of aluminium	13.88%	2.80E+00
		market for casting, steel	12.07%	2.43E+00
		market for impact extrusion of steel	9.42%	1.90E+00
	Dublin, IE	market for steel, unalloyed	19.16%	2.89E-02
		market for impact extrusion of aluminium,	17.57%	2.65E-02
		market for casting, steel	14.62%	2.21E-02
		market for acrylonitrile-butadiene-styrene copolymer	11.65%	1.76E-02
		corrugated board box production	10.39%	1.57E-02

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 M2.1, M8.1 and M10. From the results below, it is clear that the top contributors to the energy footprint of the products are related to raw material sourcing. Specifically, steel used in the arms' base clamp and vesa, and aluminum for the arm and base are significant contributors. Furthermore, the relative impacts of the top contributors are roughly the same across both final assembly locations for all three monitor arms, however, overall impacts are slightly less for the products manufactured in Dublin due to shorter transportation distances.

Table 16: Top 5 Processes Contributing to Water Footprint ReCiPe 2016 Midpoint (H)

	Final Assembly Location	Process	%	m3
M2.1	Piscataway, NJ	market for aluminium, cast alloy	29.71%	3.19E-02
		market for steel, unalloyed	21.87%	2.35E-02
		market for impact extrusion of aluminium	11.25%	1.21E-02
		market for acrylonitrile-butadiene-styrene copolymer	9.69%	1.04E-02
		market for impact extrusion of steel	9.40%	1.01E-02
	Dublin, IE	market for aluminium, cast alloy	31.13%	3.19E-02
		market for steel, unalloyed	22.91%	2.35E-02
		market for impact extrusion of aluminium	11.78%	1.21E-02
		market for acrylonitrile-butadiene-styrene copolymer	10.16%	1.04E-02
		market for impact extrusion of steel	9.84%	1.01E-02
M8.1	Piscataway, NJ	market for steel, unalloyed	18.88%	2.93E-02
		market for impact extrusion of aluminium	17.95%	2.79E-02
		market for casting, steel	15.03%	2.34E-02
		market for acrylonitrile-butadiene-styrene copolymer	10.18%	1.58E-02
		corrugated board box production	10.10%	1.57E-02
	Dublin, IE	market for steel, unalloyed	19.83%	2.93E-02
		market for impact extrusion of aluminium	18.85%	2.79E-02
		market for casting, steel	15.79%	2.34E-02
		market for acrylonitrile-butadiene-styrene copolymer	10.69%	1.58E-02
		corrugated board box production	10.61%	1.57E-02
M10	Piscataway, NJ	market for steel, unalloyed	19.16%	2.89E-02
		market for impact extrusion of aluminium	17.57%	2.65E-02
		market for casting, steel	14.62%	2.21E-02
		market for acrylonitrile-butadiene-styrene copolymer	11.65%	1.76E-02
		corrugated board box production	10.39%	1.57E-02
	Dublin, IE	market for steel, unalloyed	26.65%	4.46E+00
		market for impact extrusion of aluminium	16.72%	2.80E+00
		market for casting, steel	14.54%	2.43E+00
		market for impact extrusion of steel	11.34%	1.90E+00
		market for acrylonitrile-butadiene-styrene copolymer	8.11%	1.36E+00

5.6 SENSITIVITY ANALYSIS

Table 17: Sensitivity Analysis Results					
Factor	BIFMA Life Cycle Stage Name	Model	GWP (kg CO2 eq)		% Change
			Original	After Change	
Shipping Distance: half the mileage. (Original model assumes farthest shipping distance to customer)	Distribution, storage, and use	M2.1	1.77E+01	1.64E+01	-6.84%
		M8.1	2.71E+01	2.51E+01	-7.44%
		M10	2.66E+01	2.46E+01	-7.43%
Allocation method: economic instead of mass allocation	Production (Manufacturing / Assembly)	M2.1	1.77E+01	1.81E+01	2.61%
		M8.1	2.71E+01	2.78E+01	2.41%
		M10	2.66E+01	2.74E+01	2.93%
Electricity used in assembly: GLO instead of RFC electrical grid.	Production (Manufacturing / Assembly)	M2.1	1.77E+01	1.77E+01	0.23%
		M8.1	2.71E+01	2.72E+01	0.26%
		M10	2.66E+01	2.67E+01	0.25%
Electricity used in assembly: reduced by 10%	Production (Manufacturing / Assembly)	M2.1	1.77E+01	1.76E+01	-0.16%
		M8.1	2.71E+01	2.71E+01	-0.17%
		M10	2.66E+01	2.66E+01	-0.17%
Waste shipping: half the distance at end of life	End of Life	M2.1	1.77E+01	1.76E+01	-0.45%
		M8.1	2.71E+01	2.70E+01	-0.49%
		M10	2.66E+01	2.65E+01	-0.49%

6 INTERPRETATION

As shown in Section 5.3, 5.4 and 5.5, the top five processes within the cradle-gate (as defined by the International Living Future Institute) life cycle stages of M2.1, M8.1 and M10, 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. Increasing the amount of recycled content could have a significant benefit to the product’s cradle to gate environmental footprint. All three products have a high content of recycled aluminum. Only 3% of the aluminum in M8.1 and M10 comes from virgin sources and only 26% for M2.1. The amount of recycled steel used in these products however, is far lower. The extraction of virgin steel is a top contributor to all three products’ cradle to gate footprint. On average, steel extraction is responsible for 18.58% of the product’s upstream energy consumption, 24.99% of its upstream carbon footprint and 21.55% of its upstream water consumption. Like aluminum, increasing the amount of recycled steel content would have a beneficial impact to the products cradle to gate environmental footprint.

As stated earlier, the models in this report assume that the monitor arms 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 7.24% in the products' cradle to grave carbon footprint when shipped to a customer half as far.

The Sensitivity Analysis shows that the model is not sensitive to the Allocation Method used; mass or economic. 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 location. The analysis shows only a 2.61% change to the Global Warming Potential for M2.1, a 2.41% change for M8.1 and a 2.93% change when using an economic allocation method over a mass allocation method.

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.

In general, secondary data was of overall good quality, however the data was of poor geographic coverage. This was due to the lack of availability of regionally-specific data in the ecoinvent database. For many inputs, Global averages were used. In section 5.6, the Sensitivity Analysis compares the Global Warming Potential of the model when using Global geographical coverage for electricity instead of an electricity input specific to the manufacturing location. Using Global electricity increased the total impacts for M2.1, M8.1 and M10 by 0.23%, 0.26%, and 0.25% respectively. Although the model was not very sensitive to the geographical coverage of the electricity input, it is possible that having regional datasets for each of the inputs in which Global averaged were used could have impacted the results as whole.

7 WORKS CITED

ISO (the International Organization for Standardization) ISO 14040 Environmental management — Life cycle assessment — Principles and framework 2006

ISO (the International Organization for Standardization) ISO 14044 Environmental management — Life cycle assessment — Requirements and guidelines 2006

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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