Environmental
Product
Declaration

Lightly

Butterfly Linear Pendant

According to
ISO 21930
ISO 14025

1. General Information

Manufacturer Name:	Lightly – 7 Creek Parkway, Boothwn PA, 19061
Program Operator:	ASTM International 100 Barr Harbor Drive West Conshohocken, PA 19428-2959, USA
Declaration Number:	EPD 429
Reference PCR:	ISO 21930: 2017 with guidance from PEP ecopassport® Specific Rules for Luminaires PSR-0014-ed1.0-EN-2018 07 18
Date of Issuance:	April 17, 2023
End of Validity:	April 17, 2028
Product Name:	Butterfly Linear Pendant
EPD Owner:	Lightly
Declared Unit:	“Manufacture of a single lighting fixture”
EPD Scope:	Cradle-to-gate (A1, A2, and A3)
Verification:	ISO 21930 serves as the core PCR. Independent verification of the declaration according to ISO 14025 and ISO 21930. ☐ internal ☒ external
LCA Reviewer and EPD Verifier:	Timothy S. Brooke ASTM International

2. Product Information

2.1 Company Description

Lightly is a collection of engineers and designers that are based from Philadelphia, PA. Lightly works with teams and people around the world to design and manufacture LED light engines and luminaires.

2.2 Product Description

A luminaire as described in the functional unit consists of the following elements: a structure, a power suppy equipment system, a light source (lamp), and if applicable a lighting management system. The specific luminaire in this EPD is called a Lightly Butterfly Linear Pendant and is shown in Figure 1.

Figure 1: Visual representation of lighting product.

The product studied meets the following definition (NF EN 60598-1:2015 – Luminaires – Part 1: General requirements and tests.):

"Lighting appliance which distributes, filters or transforms the light emitted by one or more lamps and which includes, […], all the devices necessary for the bracket, fixing, and protection of the lamps and, if necessary, the auxiliary circuits and the means for connecting them to the power grid."

2.3 Technical Data

Table 1 provides product composition data for the Lightly Classic Linear Pendant lighting fixture. The weight of the classic linear pendant is 5 kgs.

Table 1: Technical Data

Component	Weight of Component (kgs)	Component Material (% breakdown)
Frame (Soft Maple, Poplar, or White Oak Wood)	2.273	25% Soft Maple, 25% Walnut, 25% White Oak, 25% Poplar
Ecos Atmosphere Purifying Paint	0.227	50% Water, 10% Titanium Dioxide, 5% Calcium Carbonate, 35% Other
Wood Gelatin Glue	0.064	60% Technical Gelatin, 30% Water, 10% Other
WoodSheild Stain	0.045	70% Water, 30% Other Chemicals
Hemp Oil	0.045	100% Refine Hemp Seed Oil
Hemp Cord	0.009	100% Hemp
Birch Dowel	0.008	100% Birch Dowel
Wool Felt	0.013	100% Wool
Flex LED Module*	0.032	56% Copper, 24% Various adhesives, 7% polyimide, 5% Phosphor bronze connectors, 4% CTBN, 4% other
Driver*	0.87	52% sheet metal, 32% electronics, 8% FR4, 8% various plastics, 2% Silicone
Driver Box*	0.45	99% steel, 1% powder coat
Wire	0.21	100% Copper

*See Table 2 for additional component information

A brief description of the Flex LED Module, Driver, and Driver Box is provided in Table 2.

Table 2: Additional Component Information

Sub-Component	Sub-Component Description
LED Systems	The LED systems include premium LEDs available in 3000K, 3500K, and 4000K with CRI>90
Driver	0-10V, 1.0% Dimming, 120-277 VAC
Driver Box	20 Gauge steel sheet metal with a powder coat

Additionally, the luminous flux ranges from 600 lm/ft to 1400 lm/ft, the color temp is 105 C, the luminous efficiency ranges from 136 lm/W to 141 lm/W, and the power ranges from 4.3 to 10.3 W/ft, and the operational lifetime is 54,000 hrs.

2.4 All Stages – Transport

All transportation data was gathered as primary data from the manufactured. Modes included truck and ocean transport.

3. LCA Calculation Rules

3.1 Declared Unit

For a full cradle-to-grave study as specified by the PSR the functional unit is “Provide lighting that delivers an outgoing artificial luminous flux of 1,000 lumens during a reference lifetime of 35,000 hours”. The scope of this EPD is “cradle-to-gate” therefore the reasonable declared unit is for the manufacture of a single lighting fixture produced at Lightly’s manufacturing facility. This EPD is developed to support a future cradle-to-grave study for the specified fixture.

3.2 System Boundary

The system boundary for this study is limited to a cradle-to-gate focus. (see also Table 4):

- ***A1 Raw material supply***: Extraction, handling, and processing of input materials. This includes all upstream processing of the separate lighting components: (structure, light source, etc.)
- ***A2 Transportation****:* Transportation of all input materials from the suppliers to the gate of the manufacturing facility.
- ***A3 Manufacturing*****:** The assembly processes at Lightly’s manufacturing facility. This phase also includes the operations of the manufacturing facility and all process emissions that occur at the production facility.

3.3 Estimates and Assumptions

All significant foreground data was gathered from the manufacturer based on measured values.

3.4 Cut-off Criteria

The cut-off criteria for all activity stage flows considered within the system boundary conform with ISO 21930: 2017 Section 7.1.8. Specifically, the cut-off criteria were applied as follows:

- All inputs and outputs for which data are available are included in the calculated effects and no collected core process data are excluded.
- A one percent cut-off is considered for renewable and non-renewable primary energy consumption and the total mass of inputs within a unit process. The sum of the total neglected flows does not exceed 5% of all energy consumption and mass of inputs.
- All flows known to contribute a significant impact or to uncertainty are included.
- The cut-off rules are not applied to hazardous and toxic material flows – all of which are included in the life cycle inventory.

No material or energy input or output was knowingly excluded from the system boundary.

Additionally, it is noted that EPDs are comparable only if they comply with this document, use the same sub-category PCR where applicable, include all revelant infromation modules and are based on equivalent scenarios with respect to the context of the construction works.

3.5 Background Data and 3.6 Data Quality

Data was gathered for the primary material and energy inputs used in production for calendar year 2021. Table 2 describes each LCI data source for raw materials (A1), transportation (A2) and the core manufacture process (A3). Table 3 also includes a data quality assessment on the basis of the technological, temporal, and geographical representativeness.

Table 2: Secondary Data Sources and Data Quality Assessment

A1: Raw Material Inputs

Inputs	LCI Data Source	Geography	Year	Data Quality Assessment
Frame	CORRIM Report: Life Cycle Assessment for the Production of Northeast – Northcentral Softwood Lumber	US	2020	**Technology:** fair **Time:** very good Data is <5 years old **Geography:** very good
Ecos Atmosphere Purifying Paint	Ecoinvent 3.7: Titanium dioxide {RoW}| market for | Cut-off, U, Calcium carbonate, precipitated {RoW}| calcium carbonate production, precipitated | Cut-off, U, Kaolin {RoW}| production | Cut-off, U, Citric acid {GLO}| market for | Cut-off, U, Water, ultrapure, at plant/GLO US-EI U, Chemicals organic, at plant/GLO US-EI U, Chemicals inorganic, at plant/GLO US-EI U, Zeolite, powder {GLO}| market for | Cut-off, U	US	2014	**Technology:** very good **Time:** good Data is <10 years old **Geography:** very good
Wood Gelatin Glue	Ecoinvent 3.7: Chemicals organic, at plant/GLO US-EI U, Chemicals inorganic, at plant/GLO US-EI U, Phenol, at plant/US- US-EI U	Global	2018	**Technology:** fair **Time:** very good Data is <5 years old **Geography:** good Data is representative of global conditions.
WoodSheild Stain	Ecoinvent 3.7: Chemicals organic, at plant/GLO US-EI U, Chemicals inorganic, at plant/GLO US-EI U, Bleaching,	US	2020	**Technology:** fair **Time:** very good Data is <5 years old **Geography:** very good

	textile {RoW}| bleaching, textile | Cut-off, U			
Hemp Oil	Ecoinvent 3.7: Chemicals organic, at plant/GLO US-EI U	US	2020	**Technology:** fair **Time:** very good Data is <5 years old **Geography:** very good
Hemp Cord	Ecoinvent 3.7: Sunn hemp plant, harvested {RoW}| sunn hemp production | Cut-off, U	US	2020	**Technology:** fair **Time:** very good Data is <5 years old **Geography:** very good
Birch Dowel	CORRIM Report: Life Cycle Assessment for the Production of Northeast – Northcentral Softwood Lumber	US	2020	**Technology:** fair **Time:** very good Data is <5 years old **Geography:** very good
Wool Felt	Ecoinvent 3.7: Wool, sheep, at farm/US with US electricity U	US	2020	**Technology:** fair **Time:** very good Data is <5 years old **Geography:** very good
Flex LED Module	Life-Cycle Assessment of Energy and Environmental Impacts of LED and Lighting Products. Part 2: LED Manufacturing and Performance. Ecoinvent 3.7: Electronics for control units/US- US-EI U, Chemicals inorganic, at plant/GLO US-EI U	China	2020	**Technology:** very good **Time:** good Data is <10 years old **Geography:** very good

Driver	Ecoinvent 3.7: Electronics for control units/US- US-EI U, Chemicals inorganic, at plant/GLO US-EI U, Silicone product {RoW}| production | Cut-off, U. World Steel Association: Cradle to gate excluding end-of-life recycling for 1kg steel product USLCI 2014: Acrylonitrile-butadiene-styrene copolymer, resin, at plant, CTR/kg/RNA	US	2020	**Technology:** fair **Time:** very good Data is <5 years old **Geography:** very good
Driver Box	USLCI 2014: Acrylonitrile-butadiene-styrene copolymer, resin, at plant, CTR/kg/RNA	US	2014	**Technology:** fair **Time:** good Data is <10 years old **Geography:** very good
Wire	Ecoinvent 3.7: Copper wire, technology mix, consumption mix, at plant, cross section 1 mm² EU-15 S	US	2020	**Technology:** fair **Time:** very good Data is <5 years old **Geography:** very good

A2: Transportation				
Inputs	**LCI Data Source**	**Geography**	**Year**	**Data Quality Assessment**
Trucking	USLCI: Transport, single unit truck, short-haul, diesel powered, Northwest/tkm/RNA	Global	2014	**Technology:** very good **Time:** good Data is <10 years old **Geography:** very good
Rail	USLCI: Transport, train, diesel powered/US	Global	2014	**Technology:** very good **Time:** good Data is <10 years old **Geography:** very good

A3: Manufacturing

Energy	LCI Data Source	Geography	Year	Data Quality Assessment
Electricity – LED manufacturing	Ecoinvent 3.7: Electricity, medium voltage {CN}| market group for | Cut-off, U	China	2018	**Technology:** very good **Time:** very good Data is <5 years old **Geography:** very good
Electricity – Fixture manufacturing	Ecovinent 3.7: Electricity, medium voltage {US}| market group for | Cut-off, U	US	2018	**Technology:** very good **Time:** very good Data is <5 years old **Geography:** very good.
Packaging	USLCI: Packaging, corrugated board, mixed fibre, single wall, at plant/US- US-EI U	US	2014	**Technology:** very good **Time:** good Data is <10 years old **Geography:** very good.

3.7 Period under Review

Data was gathered for the primary material and energy inputs used in the production for calendar year 2021.

3.8 Allocation

Lightly's manufacturing facility produces multiple products. Since the primary data for manufacturing was only available on a facility level, the environmental load among the products produced is allocated according to its mass. For waste that is recycled, the 'recycled content approach' was chosen. The recycling of waste generated by the product system is cut off.

3.9 Comparability

This LCA was created using industry average data for upstream materials. Data variation can result from differences in supplier locations, manufacturing processes, manufacturing efficiency and fuel types used.

4. LCA Results

Life cycle impact assessment (LCIA) is the phase in which the set of results of the inventory analysis – the inventory flow table – is further processed and interpreted in terms of environmental impacts and resource use inventory metrics.Tables 3 and 4 below summmarize the LCA results for the cradle-to-gate (A1-A3) product system.

Table 3: Description of the System Boundary (x: included in LCA; mnd: module not declared; mnr: module not reported)

Product			**Construction Installation**		**Use**							**End-of-Life**				**Benefits Beyond the System Boundary**		
Raw Material Supply	Transport	Manufacturing	Transport	Construction / Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/ Demolition	Transport	Waste Processing	Disposal	Reuse	Recovery	Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D
x	x	x	mnd	mnd	mnd	mnd	mnr	mnr	mnr	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd	mnd

Table 4. LCA Results for Cradle-To-Gate Production of Butterfly Linear Pendant						
Environmental Indicator	**Abbreviation**	**Units**	**Total**	**A1**	**A2**	**A3**
Core Mandatory Impact Indicator						
Global warming potential	**GWP**	kg CO_2-eq	2.64E+01	2.58E+01	5.35E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	**ODP**	kg CFC-11-eq	9.63E-07	9.60E-07	2.03E-11	3.29E-09
Acidification potential of land and water	**AP**	kg SO_2-eq	1.35E-01	1.28E-01	6.94E-03	1.35E-04
Eutrophication potential	**EP**	kg PO_4-eq	1.49E-01	1.48E-01	3.78E-04	2.87E-04
Formation of tropospheric ozone	**SFP**	kg O_3-eq	1.60E+00	1.40E+00	2.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	**ADPf**	MJ Surplus	2.29E+02	2.22E+02	6.84E+00	5.69E-01
Fossil fuel depletion	**FFD**	MJ Surplus	1.60E+01	1.49E+01	1.02E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	**RPRE**	MJ	3.72E+01	3.71E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	**RPRM**	MJ	5.17E+01	5.17E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	**NRPRE**	MJ	2.67E+02	2.59E+02	7.25E+00	9.04E-01
Non-renewable primary energy used as material	**NRPRM**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Secondary Material, Secondary Fuel and Recovered Energy						
Use of secondary materials	**SM**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	**RSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary fuels	**NRSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy	**RE**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mandatory Inventory Parameters						
Use of freshwater resources	**FW**	m^3	1.81E-01	1.81E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	**HWD**	kg	2.54E-05	2.54E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	**NHWD**	kg	2.93E-02	2.93E-02	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	**HLRW**	m^3	1.30E-08	1.28E-08	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	**LLRW**	m^3	9.32E-08	9.19E-08	0.00E+00	1.34E-09
Components for reuse	**CRU**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	**MFR**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	**MER**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy Exported	**EE**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5. Interpretation

Figure 2 shows the relative contribution to the cumulative impacts of the A1 through A3 phases of the cradle-to-gate life cycle. For all the major impact categories (GWP, ODP, AP, EP, SFP, ADPf), the biggest contributor is A1 – Raw material supply. This includes the upstream emissions of all materials used to produce the luminaire. There are some contributions from A2 – Transportation, and very little from A3 – Manufacturing.

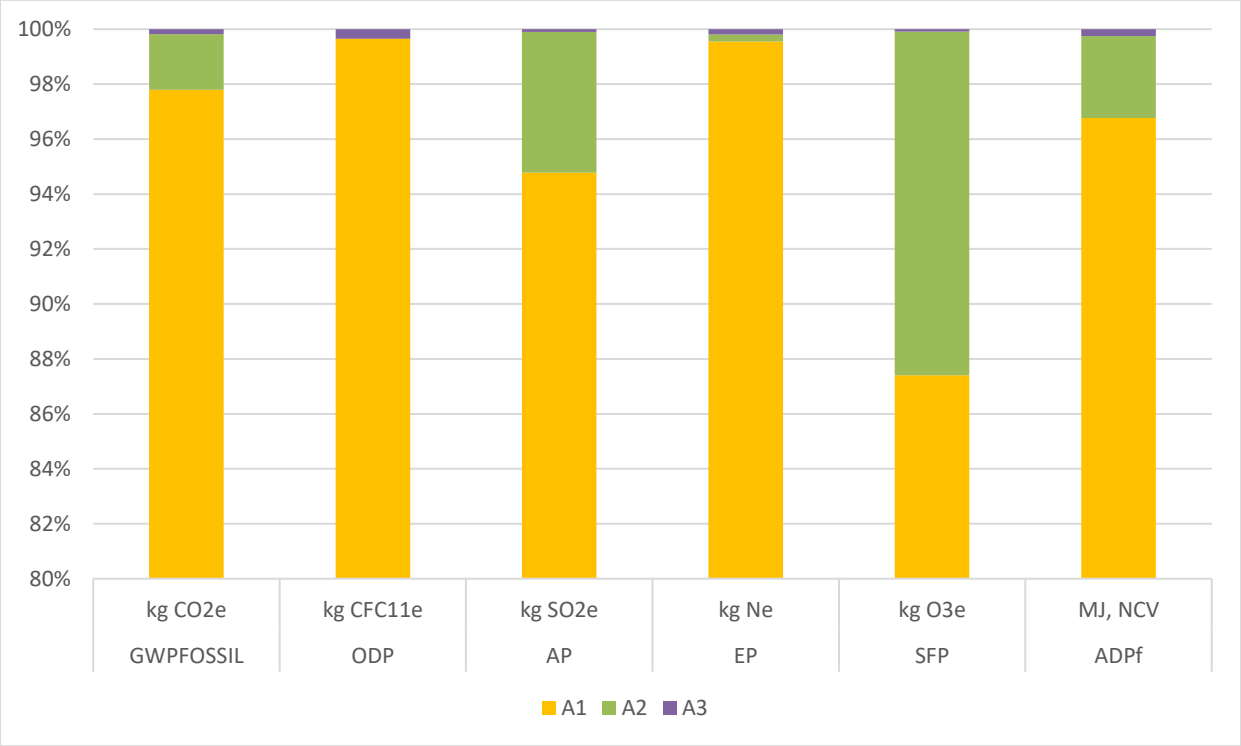

Figure 2. Contribution analysis for the Lightly Classic Butterfly Linear Pendant

6. References

1. PEP Ecopassport PROGRAM – PSR Specific Rules for Luminaires, PSR-0014-ED1.0-EN-2018 07 18.

2. Athena Institute: 2022 - A Cradle-to-Gate Life Cycle Assessment of Luminaires Manufactured by Lightly

3. ISO 21930: 2017 Building construction – Sustainability in building construction – Environmental declaration of building products.

4. ISO 14025: 2006 Environmental labeling and declarations - Type III environmental declarations - Principles and procedures.

5. ISO 14044:2006/AMD 1:2017/ AMD 2:2020 - Environmental management - Life cycle assessment - Requirements and guidelines.

6. 14040:2006/AMD 1:2020 - Environmental management - Life cycle assessment - Principles and framework.

7. Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products, Part 2: LED Manufacturing and Performance, May 2012.

Appendix A – Additional Variations

Table 5. LCIA Results for Cradle-To-Gate Production Direct Only						
Environmental Indicator	**Abbreviation**	**Units**	**Total**	**A1**	**A2**	**A3**
Core Mandatory Impact Indicator						
Global warming potential	**GWP**	kg CO_2-eq	2.55E+01	2.49E+01	5.35E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	**ODP**	kg CFC-11-eq	9.15E-07	9.12E-07	2.03E-11	3.29E-09
Acidification potential of land and water	**AP**	kg SO_2-eq	1.25E-01	1.18E-01	6.94E-03	1.35E-04
Eutrophication potential	**EP**	kg PO_4-eq	1.45E-01	1.45E-01	3.78E-04	2.87E-04
Formation of tropospheric ozone	**SFP**	kg O_3-eq	1.54E+00	1.33E+00	2.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	**ADPf**	MJ Surplus	2.23E+02	2.16E+02	6.84E+00	5.69E-01
Fossil fuel depletion	**FFD**	MJ Surplus	1.54E+01	1.43E+01	1.02E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	**RPRE**	MJ	2.85E+01	2.84E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	**RPRM**	MJ	3.43E+01	3.43E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	**NRPRE**	MJ	2.60E+02	2.52E+02	7.25E+00	9.04E-01
Non-renewable primary energy used as material	**NRPRM**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Secondary Material, Secondary Fuel and Recovered Energy						
Use of secondary materials	**SM**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	**RSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary	**NRSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy	**RE**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mandatory Inventory Parameters						
Use of freshwater resources	**FW**	m^3	1.75E-01	1.75E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	**HWD**	kg	1.69E-05	1.69E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	**NHWD**	kg	1.95E-02	1.95E-02	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	**HLRW**	m^3	1.27E-08	1.26E-08	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	**LLRW**	m^3	9.18E-08	9.05E-08	0.00E+00	1.34E-09
Components for reuse	**CRU**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	**MFR**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	**MER**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy Exported	**EE**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 6. LCIA Results for Cradle-To-Gate Production Indirect Only						
Environmental Indicator	**Abbreviation**	**Units**	**Total**	**A1**	**A2**	**A3**
Core Mandatory Impact Indicator						
Global warming potential	**GWP**	kg CO_2-eq	2.54E+01	2.48E+01	5.35E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	**ODP**	kg CFC-11-eq	9.08E-07	9.04E-07	2.03E-11	3.29E-09
Acidification potential of land and water	**AP**	kg SO_2-eq	1.24E-01	1.17E-01	6.94E-03	1.35E-04
Eutrophication potential	**EP**	kg PO_4-eq	1.45E-01	1.44E-01	3.78E-04	2.87E-04
Formation of tropospheric ozone	**SFP**	kg O_3-eq	1.52E+00	1.32E+00	2.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	**ADPf**	MJ Surplus	2.23E+02	2.15E+02	6.84E+00	5.69E-01
Fossil fuel depletion	**FFD**	MJ Surplus	1.53E+01	1.42E+01	1.02E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	**RPRE**	MJ	2.69E+01	2.68E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	**RPRM**	MJ	2.95E+01	2.95E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	**NRPRE**	MJ	2.59E+02	2.51E+02	7.25E+00	9.04E-01
Non-renewable primary energy used as material	**NRPRM**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Secondary Material, Secondary Fuel and Recovered Energy						
Use of secondary materials	**SM**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	**RSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary	**NRSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy	**RE**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mandatory Inventory Parameters						
Use of freshwater resources	**FW**	m^3	1.74E-01	1.74E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	**HWD**	kg	1.45E-05	1.45E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	**NHWD**	kg	1.67E-02	1.67E-02	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	**HLRW**	m^3	1.27E-08	1.25E-08	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	**LLRW**	m^3	9.16E-08	9.03E-08	0.00E+00	1.34E-09
Components for reuse	**CRU**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	**MFR**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	**MER**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy Exported	**EE**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 7. LCIA Results for Cradle-To-Gate Production Direct/Indirect 3.125" Open						
Environmental Indicator	**Abbreviation**	**Units**	**Total**	**A1**	**A2**	**A3**
Core Mandatory Impact Indicator						
Global warming potential	**GWP**	kg CO_2-eq	4.22E+01	4.16E+01	5.35E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	**ODP**	kg CFC-11-eq	1.28E-06	1.28E-06	2.03E-11	3.29E-09
Acidification potential of land and water	**AP**	kg SO_2-eq	1.99E-01	1.92E-01	6.94E-03	1.35E-04
Eutrophication potential	**EP**	kg PO_4-eq	2.41E-01	2.40E-01	3.78E-04	2.87E-04
Formation of tropospheric ozone	**SFP**	kg O_3-eq	2.36E+00	2.16E+00	2.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	**ADPf**	MJ Surplus	3.46E+02	3.39E+02	6.84E+00	5.69E-01
Fossil fuel depletion	**FFD**	MJ Surplus	2.18E+01	2.07E+01	1.02E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	**RPRE**	MJ	4.73E+01	4.73E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	**RPRM**	MJ	6.36E+01	6.36E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	**NRPRE**	MJ	4.02E+02	3.94E+02	7.25E+00	9.04E-01
Non-renewable primary energy used as material	**NRPRM**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Secondary Material, Secondary Fuel and Recovered Energy						
Use of secondary materials	**SM**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	**RSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary	**NRSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy	**RE**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mandatory Inventory Parameters						
Use of freshwater resources	**FW**	m^3	2.74E-01	2.73E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	**HWD**	kg	3.12E-05	3.12E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	**NHWD**	kg	3.61E-02	3.61E-02	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	**HLRW**	m^3	1.84E-08	1.82E-08	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	**LLRW**	m^3	1.25E-07	1.23E-07	0.00E+00	1.34E-09
Components for reuse	**CRU**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	**MFR**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	**MER**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy Exported	**EE**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 8. LCIA Results for Cradle-To-Gate Production Direct/Indirect 6" Open						
Environmental Indicator	**Abbreviation**	**Units**	**Total**	**A1**	**A2**	**A3**
Core Mandatory Impact Indicator						
Global warming potential	**GWP**	kg CO_2-eq	4.36E+01	4.31E+01	5.35E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	**ODP**	kg CFC-11-eq	1.35E-06	1.35E-06	2.03E-11	3.29E-09
Acidification potential of land and water	**AP**	kg SO_2-eq	2.15E-01	2.08E-01	6.94E-03	1.35E-04
Eutrophication potential	**EP**	kg PO_4-eq	2.47E-01	2.46E-01	3.78E-04	2.87E-04
Formation of tropospheric ozone	**SFP**	kg O_3-eq	2.43E+00	2.23E+00	2.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	**ADPf**	MJ Surplus	3.54E+02	3.47E+02	6.84E+00	5.69E-01
Fossil fuel depletion	**FFD**	MJ Surplus	2.26E+01	2.15E+01	1.02E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	**RPRE**	MJ	5.71E+01	5.70E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	**RPRM**	MJ	6.36E+01	6.36E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	**NRPRE**	MJ	4.11E+02	4.03E+02	7.25E+00	9.04E-01
Non-renewable primary energy used as material	**NRPRM**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Secondary Material, Secondary Fuel and Recovered Energy						
Use of secondary materials	**SM**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	**RSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary	**NRSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy	**RE**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mandatory Inventory Parameters						
Use of freshwater resources	**FW**	m^3	2.82E-01	2.82E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	**HWD**	kg	3.12E-05	3.12E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	**NHWD**	kg	3.61E-02	3.61E-02	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	**HLRW**	m^3	1.89E-08	1.87E-08	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	**LLRW**	m^3	1.27E-07	1.26E-07	0.00E+00	1.34E-09
Components for reuse	**CRU**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	**MFR**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	**MER**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy Exported	**EE**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 9. LCIA Results for Cradle-To-Gate Production Direct/Indirect 12" Open						
Environmental Indicator	**Abbreviation**	**Units**	**Total**	**A1**	**A2**	**A3**
Core Mandatory Impact Indicator						
Global warming potential	**GWP**	kg CO_2-eq	4.66E+01	4.60E+01	5.35E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	**ODP**	kg CFC-11-eq	1.49E-06	1.49E-06	2.03E-11	3.29E-09
Acidification potential of land and water	**AP**	kg SO_2-eq	2.49E-01	2.42E-01	6.94E-03	1.35E-04
Eutrophication potential	**EP**	kg PO_4-eq	2.60E-01	2.59E-01	3.78E-04	2.87E-04
Formation of tropospheric ozone	**SFP**	kg O_3-eq	2.58E+00	2.38E+00	2.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	**ADPf**	MJ Surplus	3.70E+02	3.62E+02	6.84E+00	5.69E-01
Fossil fuel depletion	**FFD**	MJ Surplus	2.42E+01	2.32E+01	1.02E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	**RPRE**	MJ	7.74E+01	7.73E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	**RPRM**	MJ	6.36E+01	6.36E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	**NRPRE**	MJ	4.30E+02	4.22E+02	7.25E+00	9.04E-01
Non-renewable primary energy used as material	**NRPRM**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Secondary Material, Secondary Fuel and Recovered Energy						
Use of secondary materials	**SM**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	**RSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary	**NRSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy	**RE**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mandatory Inventory Parameters						
Use of freshwater resources	**FW**	m^3	3.01E-01	3.00E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	**HWD**	kg	3.12E-05	3.12E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	**NHWD**	kg	3.61E-02	3.61E-02	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	**HLRW**	m^3	1.99E-08	1.97E-08	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	**LLRW**	m^3	1.32E-07	1.31E-07	0.00E+00	1.34E-09
Components for reuse	**CRU**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	**MFR**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	**MER**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy Exported	**EE**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 10. LCIA Results for Cradle-To-Gate Production Direct/Indirect 6" Acoustic						
Environmental Indicator	**Abbreviation**	**Units**	**Total**	**A1**	**A2**	**A3**
Core Mandatory Impact Indicator						
Global warming potential	**GWP**	kg CO_2-eq	6.28E+01	6.22E+01	5.35E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	**ODP**	kg CFC-11-eq	2.28E-06	2.28E-06	2.03E-11	3.29E-09
Acidification potential of land and water	**AP**	kg SO_2-eq	4.34E-01	4.27E-01	6.94E-03	1.35E-04
Eutrophication potential	**EP**	kg PO_4-eq	3.31E-01	3.31E-01	3.78E-04	2.87E-04
Formation of tropospheric ozone	**SFP**	kg O_3-eq	3.41E+00	3.21E+00	2.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	**ADPf**	MJ Surplus	4.57E+02	4.49E+02	6.84E+00	5.69E-01
Fossil fuel depletion	**FFD**	MJ Surplus	3.34E+01	3.23E+01	1.02E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	**RPRE**	MJ	1.90E+02	1.89E+02	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	**RPRM**	MJ	7.09E+01	7.09E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	**NRPRE**	MJ	5.34E+02	5.25E+02	7.25E+00	9.04E-01
Non-renewable primary energy used as material	**NRPRM**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Secondary Material, Secondary Fuel and Recovered Energy						
Use of secondary materials	**SM**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	**RSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary	**NRSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy	**RE**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mandatory Inventory Parameters						
Use of freshwater resources	**FW**	m^3	4.01E-01	4.01E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	**HWD**	kg	3.48E-05	3.48E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	**NHWD**	kg	4.02E-02	4.02E-02	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	**HLRW**	m^3	2.57E-08	2.55E-08	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	**LLRW**	m^3	1.60E-07	1.58E-07	0.00E+00	1.34E-09
Components for reuse	**CRU**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	**MFR**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	**MER**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy Exported	**EE**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 11. LCIA Results for Cradle-To-Gate Production Direct/Indirect 12”						
Environmental Indicator	**Abbreviation**	**Units**	**Total**	**A1**	**A2**	**A3**
Core Mandatory Impact Indicator						
Global warming potential	**GWP**	kg CO_2-eq	1.02E+02	1.01E+02	5.35E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	**ODP**	kg CFC-11-eq	4.18E-06	4.18E-06	2.03E-11	3.29E-09
Acidification potential of land and water	**AP**	kg SO_2-eq	8.81E-01	8.74E-01	6.94E-03	1.35E-04
Eutrophication potential	**EP**	kg PO_4-eq	5.04E-01	5.03E-01	3.78E-04	2.87E-04
Formation of tropospheric ozone	**SFP**	kg O_3-eq	5.41E+00	5.20E+00	2.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	**ADPf**	MJ Surplus	6.66E+02	6.58E+02	6.84E+00	5.69E-01
Fossil fuel depletion	**FFD**	MJ Surplus	5.54E+01	5.43E+01	1.02E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	**RPRE**	MJ	4.59E+02	4.59E+02	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	**RPRM**	MJ	7.96E+01	7.96E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	**NRPRE**	MJ	7.82E+02	7.74E+02	7.25E+00	9.04E-01
Non-renewable primary energy used as material	**NRPRM**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Secondary Material, Secondary Fuel and Recovered Energy						
Use of secondary materials	**SM**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	**RSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary	**NRSF**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered energy	**RE**	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mandatory Inventory Parameters						
Use of freshwater resources	**FW**	m^3	6.43E-01	6.43E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	**HWD**	kg	3.91E-05	3.91E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	**NHWD**	kg	4.51E-02	4.51E-02	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	**HLRW**	m^3	3.95E-08	3.93E-08	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	**LLRW**	m^3	2.26E-07	2.25E-07	0.00E+00	1.34E-09
Components for reuse	**CRU**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	**MFR**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	**MER**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy Exported	**EE**	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00