

Environmental Product Declaration

STICKBULB

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Treeline



ASTM INTERNATIONAL

According to
ISO 21930
ISO 14025

1. General Information

Manufacturer Name:	Stickbulb – 10-40 46 th Ave, Long Island City, NY 11101
Program Operator:	ASTM International 100 Barr Harbor Drive West Conshohocken, PA 19428-2959, USA
Declaration Number:	EPD 622
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:	July 16, 2024
End of Validity:	July 16, 2029
Product Name:	Treeline
EPD Owner:	Stickbulb
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. <input type="checkbox"/> internal <input checked="" type="checkbox"/> external
LCA Reviewer and EPD Verifier:	Timothy S. Brooke ASTM International 

2. Product Information

2.1 Company Description

Founded in NYC in 2012, Stickbulb is a Climate Neutral B-Corp that engineers modern lighting from salvaged and sustainably sourced wood.

2.2 Product Description

A luminaire as described in the functional unit consists of the following elements: a structure, a power supply equipment system, a light source (lamp), and if applicable a lighting management system. The product is rated at 7,200 lumens for the 4ft fixture and 14,400 lumens for the 8ft product. The specific luminaire in this EPD is called a Treeline as 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

The fixture contains a direct and indirect driver with a steel enclosed UL and RoHs compliant LED drivers. 0-10V, LDE, or Dali 2. Additionally, the following specifications apply to the luminaire:

- luminous flux: 7200LM for 4ft and 14400LM for 8ft
- nominal operator voltage: 120-277 VAC
- color temp: 2700, 3000, 3500, 4000, Custom
- protection index: IP06
- impact resistance: unrated
- luminous efficiency: 132lm/W to 160 lm/W
- electrical power: 3.7W/ft to 8.325W/ft
- operational lifetime: 54,000 hrs

Tables 1 provides material component weight data in both imperial and metric units for the Treeline illumination lighting fixture.

Table 1: Component weights								
Material (approximate weights)	Four Foot		Five Foot		Six Foot		Eight Foot	
	lbs	kg	lbs	kg	lbs	kg	lbs	kg
	Wood Enclosure	3.20	1.45	4.00	1.81	4.80	2.18	6.40
Channels	0.82	0.37	1.02	0.46	1.23	0.56	1.63	0.74
Hook	0.02	0.01	0.02	0.01	0.03	0.01	0.03	0.01
Header	0.33	0.15	0.33	0.15	0.33	0.15	0.33	0.15
Lanyard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustable Cable Gripper	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01
LED	0.35	0.16	0.45	0.20	0.56	0.25	0.70	0.32
Drivers	1.12	0.51	1.12	0.51	1.12	0.51	1.12	0.51
Lens	0.44	0.20	0.55	0.25	0.66	0.30	0.88	0.40
Wires	0.31	0.14	0.31	0.14	0.31	0.14	0.31	0.14
Wire Clips	0.06	0.03	0.06	0.03	0.06	0.03	0.06	0.03
Screws	0.04	0.02	0.05	0.02	0.06	0.03	0.07	0.03

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”. This scope of this EPD is “cradle-to-gate” therefore the reasonable declared unit is for the manufacture of a single lighting fixture produced at Stickbulb’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 Stickbulb’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.

3.5 Background Data and 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
Wood Enclosure	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
Wood Finish	Ecoinvent 3.7: Chemicals organic, at plant/GLO US-EI U, Chemicals inorganic, at plant/GLO US-EI U, Bleaching, textile {RoW} bleaching, textile Cut-off, U	US	2020	Technology: fair Time: very good Data is <5 years old Geography: very good
C Channel, L Channel, L Hook, Header, Header Endcap, Lanyard, Adjustable Cable Gripper	Ecoinvent 3.7: Aluminium, production mix, at plant/US-US-EI U	US	2020	Technology: fair Time: very good Data is <5 years old Geography: very good
Screws	World Steel Association: Cradle to gate excluding end-of-life recycling for 1kg steel product	Global	2021	Technology: very good Process models average global technology Time: very good Data is <5 years old Geography: very good Data is representative of global conditions.
Lens	Ecoinvent 3.7: Polycarbonate, at plant/US- US-EI U	US	2020	Technology: fair Time: very good Data is <5 years old Geography: very good
LED Lamp	Sphera: GLO: LED SMD high-efficiency with lens max 1A (60mg) Flip Chip 3.5x3.5x2.0 Sphera	Global	2023	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	US	2020	Technology: fair Time: very good Data is <5 years old Geography: very good
Wire	Ecoinvent 3.7: Copper wire, technology mix, consumption mix, at plant, cross section 1 mm ² 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
Ocean	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
Natural Gas	USLCI: Natural gas, combusted in industrial boiler/US	US	2014	Technology: very good Time: very good Data is <5 years old Geography: very good.
Electricity – Fixture manufacturing	Ecoinvent 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

Stickbulb’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 summarize 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. LCIA Results for Cradle-To-Gate Production of Four Foot Treeline Fixture						
Environmental Indicator	Abbreviation	Units	Total	A1	A2	A3
Core Mandatory Impact Indicator						
Global warming potential	GWP	kg CO ₂ -eq	3.18E+01	3.08E+01	9.96E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	ODP	kg CFC-11-eq	5.08E-07	5.05E-07	3.79E-11	3.29E-09
Acidification potential of land and water	AP	kg SO ₂ -eq	2.13E-01	2.02E-01	1.05E-02	1.35E-04
Eutrophication potential	EP	kg PO ₄ -eq	1.50E-01	1.49E-01	5.74E-04	2.87E-04
Formation of tropospheric ozone	SFP	kg O ₃ -eq	2.39E+00	2.09E+00	3.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	ADPF	MJ Surplus	1.04E+02	9.09E+01	1.28E+01	5.69E-01
Fossil fuel depletion	FFD	MJ Surplus	9.38E+00	7.43E+00	1.90E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	RPRE	MJ	4.18E+01	4.18E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	RPRM	MJ	4.12E+01	4.12E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	NRPRE	MJ	3.31E+02	3.16E+02	1.35E+01	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	2.01E-01	2.01E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	HWD	kg	2.04E-05	2.04E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	NHWD	kg	5.57E+00	5.57E+00	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	HLRW	m ³	2.61E-06	2.61E-06	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	LLRW	m ³	1.61E-03	1.61E-03	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 5. LCIA Results for Cradle-To-Gate Production of Five Foot Treeline Fixture

Environmental Indicator	Abbreviation	Units	Total	A1	A2	A3
Core Mandatory Impact Indicator						
Global warming potential	GWP	kg CO ₂ -eq	3.79E+01	3.69E+01	9.96E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	ODP	kg CFC-11-eq	5.36E-07	5.32E-07	3.79E-11	3.29E-09
Acidification potential of land and water	AP	kg SO ₂ -eq	2.87E-01	2.77E-01	1.05E-02	1.35E-04
Eutrophication potential	EP	kg PO ₄ -eq	2.69E-01	2.68E-01	5.74E-04	2.87E-04
Formation of tropospheric ozone	SFP	kg O ₃ -eq	2.88E+00	2.58E+00	3.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	ADPF	MJ Surplus	1.14E+02	1.01E+02	1.28E+01	5.69E-01
Fossil fuel depletion	FFD	MJ Surplus	1.03E+01	8.31E+00	1.90E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	RPRE	MJ	5.09E+01	5.08E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	RPRM	MJ	5.15E+01	5.15E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	NRPRE	MJ	3.89E+02	3.75E+02	1.35E+01	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	2.44E-01	2.44E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	HWD	kg	2.55E-05	2.55E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	NHWD	kg	6.85E+00	6.85E+00	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	HLRW	m ³	3.21E-06	3.21E-06	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	LLRW	m ³	1.99E-03	1.99E-03	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 of Six Foot Treeline Fixture

Environmental Indicator	Abbreviation	Units	Total	A1	A2	A3
Core Mandatory Impact Indicator						
Global warming potential	GWP	kg CO ₂ -eq	4.38E+01	4.27E+01	9.96E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	ODP	kg CFC-11-eq	5.42E-07	5.38E-07	3.79E-11	3.29E-09
Acidification potential of land and water	AP	kg SO ₂ -eq	3.18E-01	3.08E-01	1.05E-02	1.35E-04
Eutrophication potential	EP	kg PO ₄ -eq	2.71E-01	2.70E-01	5.74E-04	2.87E-04
Formation of tropospheric ozone	SFP	kg O ₃ -eq	3.25E+00	2.95E+00	3.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	ADPF	MJ Surplus	1.20E+02	1.07E+02	1.28E+01	5.69E-01
Fossil fuel depletion	FFD	MJ Surplus	1.07E+01	8.79E+00	1.90E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	RPRE	MJ	5.89E+01	5.88E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	RPRM	MJ	6.18E+01	6.18E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	NRPRE	MJ	4.44E+02	4.29E+02	1.35E+01	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	2.74E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	HWD	kg	3.06E-05	3.06E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	NHWD	kg	8.15E+00	8.15E+00	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	HLRW	m ³	3.81E-06	3.81E-06	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	LLRW	m ³	2.36E-03	2.36E-03	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 of Eight Foot Treeline Fixture

Environmental Indicator	Abbreviation	Units	Total	A1	A2	A3
Core Mandatory Impact Indicator						
Global warming potential	GWP	kg CO ₂ -eq	5.51E+01	5.41E+01	9.96E-01	4.95E-02
Depletion potential of the stratospheric ozone layer	ODP	kg CFC-11-eq	5.53E-07	5.49E-07	3.79E-11	3.29E-09
Acidification potential of land and water	AP	kg SO ₂ -eq	3.79E-01	3.68E-01	1.05E-02	1.35E-04
Eutrophication potential	EP	kg PO ₄ -eq	2.74E-01	2.73E-01	5.74E-04	2.87E-04
Formation of tropospheric ozone	SFP	kg O ₃ -eq	3.98E+00	3.68E+00	3.00E-01	1.36E-03
Abiotic depletion potential for fossil resources	ADPF	MJ Surplus	1.29E+02	1.16E+02	1.28E+01	5.69E-01
Fossil fuel depletion	FFD	MJ Surplus	1.14E+01	9.47E+00	1.90E+00	5.22E-02
Use of Primary Resources						
Renewable primary energy carrier used as energy	RPRE	MJ	7.48E+01	7.47E+01	0.00E+00	8.29E-02
Renewable primary energy carrier used as material	RPRM	MJ	8.23E+01	8.23E+01	0.00E+00	0.00E+00
Non-renewable primary energy used as energy	NRPRE	MJ	5.51E+02	5.37E+02	1.35E+01	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	3.33E-01	3.32E-01	0.00E+00	2.42E-04
Indicators Describing Waste						
Disposed of hazardous waste	HWD	kg	4.08E-05	4.08E-05	0.00E+00	0.00E+00
Disposed of non-hazardous waste	NHWD	kg	1.07E+01	1.07E+01	0.00E+00	0.00E+00
Disposed of high-level radioactive waste	HLRW	m ³	5.01E-06	5.01E-06	0.00E+00	1.67E-10
Disposed of low-level radioactive waste	LLRW	m ³	3.11E-03	3.11E-03	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.

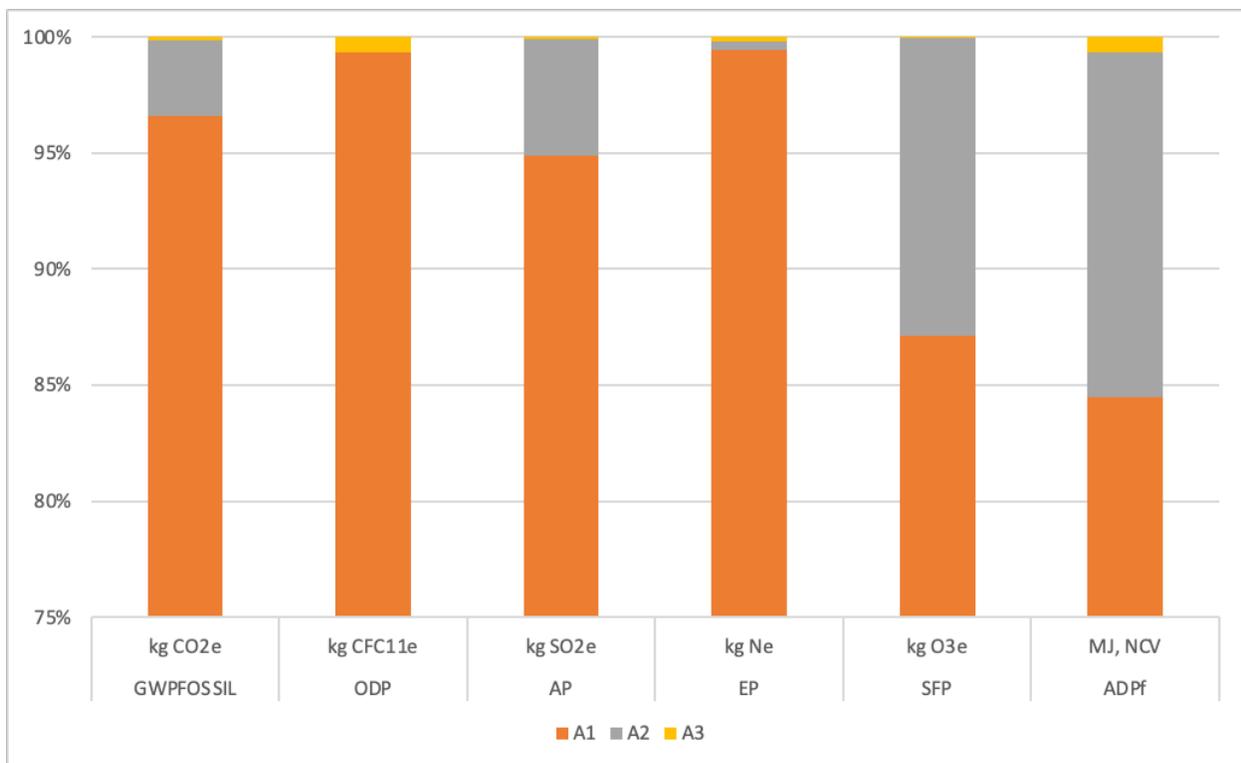


Figure 2. Contribution analysis for 4 Foot Treeline

6. References

1. PEP Ecopassport PROGRAM – PSR Specific Rules for Luminaires, PSR-0014-ED1.0-EN-2018 07 18.
2. WAP Sustainability: 2023 - A Cradle-to-Gate Life Cycle Assessment of Luminaires Manufactured by Stickbulb.
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.