LIFE CYCLE ASSESSMENT OF SPROUT MAKEUP LINERS

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ONE SPROUT MAKEUP LINER HAS AN ESTIMATED GREENHOUSE GAS EMISSION OF

25 GRAMS OF CO_2 EQUIVALENTS*

IN ITS WHOLE LIFE CYCLE FROM EXTRACTION OF MATERIALS THROUGH PRODUCTION, DISTRIBUTION, USE AND FINAL DISPOSAL.

ALLERGY CERTIFIED

*FOSSIL CO_2 EQUIVALENT EMISSIONS. THE OVERALL BIOGENIC EMISSIONS ARE -10 G CO_2 PER MAKEUP LINER MEANING A NET REMOVAL OF BIOGENIC CO_2 FROM THE ATMOSPHERE. THE RESULT PRESENTED HERE IS BASED ON SOME AVERAGE SCENARIOS FOR THE LIFE CYCLE OF THE SPROUT MAKEUP LINER, WHICH ARE UNFOLDED IN OUR SPROUT MAKEUP LINER LIFE CYCLE ASSESSMENT.

1 SUMMARY

A life cycle assessment of the Sprout makeup liner has been carried out to gain insight into the environmental impacts of producing, using and disposing of the makeup liner. The Sprout makeup liner consists of a wooden casing, a makeup formula of natural ingredients, a lid made of bio-based sugarcane polyethylene, a capsule made of cellulosic material, some clear school glue to attach the cap to the wooden casing, and some wildflower seeds and wood flour inside the cap. The makeup liners are packed in small boxes of cardboard with 1, 2 or 3 liners inside. The materials for the makeup liner and its packaging are sourced from various regions in the world. The makeup liner and packaging are produced in Europe. Delivery to an average customer in Europe has been included in the life cycle assessment. Average scenarios for disposal of product packaging, wood shavings, wood stub, capsule and lid have also been assessed. Finally, the environmental impact of planting the seeds have been roughly estimated. The Sprout makeup liner has an estimated greenhouse gas emission of 25 grams of CO_2 equivalents in its whole life cycle from extraction of materials through production, distribution, use and final disposal.

Overall, the most contributing processes to the environmental impacts of the Sprout liner are the materials and manufacturing of the product packaging and the makeup formula. The product packaging weighs more than the Sprout liner itself, and the best way to reduce the packaging impact is to reduce the amount of packaging. The production region also influences the impact of the packaging due to the electricity grid mix. The makeup formula consists of oil-, wax and glycerine-based ingredients and some pigments. Although of natural origin, these ingredients still have some impact on the environment due to their raw materials and production processes.

Although the assembly does not contribute largely to the environmental impacts, there is still some potential to reduce the impacts by minimizing electricity use and increasing the use of renewable energy sources. Transport of the product by truck to a customer in Europe does not show a large contribution to the environmental impact of the Sprout makeup liner. Transport by air i.e. to a customer in the US has significant impact on the fossil resource use and emissions for the Sprout makeup liner life cycle.

Plant growth and decay shows some impact in the biogenic CO2 emissions and uptake categories. This indicates that the plants have the potential to even out some of the CO2 that is released by other processes in the life cycle. Nevertheless, this part of the life cycle of the Sprout makeup liner is highly uncertain since it requires the customer to plant the pencil after use, and because there was a lack of data for this part of the LCA. The results regarding growth and decay of the wildflowers should be used with care.

2 INTRODUCTION

Sprout™ is a company that specializes in the design and production of plantable pencils. Since 2013 Sprout has sold more than 40 million plantable pencils in over 80 countries worldwide. The Sprout pencil has a capsule at the bottom which contains plant seeds – a characteristic that sets it apart from other pencils. When the pencil has been used the remaining part can be planted by placing the capsule-end in soil, placing it in a sunny spot and watering it. The capsule will decompose and the seeds will sprout.

Taking the idea behind the plantable Sprout pencil, Sprout has now developed the Sprout makeup liners. Sprout makeup liners are made from certified wood with a vegan and AllergyCertified makeup formula that is made by natural ingredients.

To gain further insight into the environmental impacts Sprout has assessed the makeup liner through life cycle assessment (LCA). The LCA was carried out by an environmental consultancy in close contact and collaboration with Sprout. Sprout and their suppliers have delivered the data required for carrying out the LCA.

3 GOAL OF THE LCA

This study uses LCA to estimate the potential environmental impacts in the full life cycle of Sprout makeup liners. The main goals are:

(1) to let Sprout understand the environmental profile of their products and which materials and processes in the life cycle contribute the most to the environmental impacts

(2) to communicate transparently about the environmental profile of Sprout makeup liners

Hence, the results will potentially be used to inform future design choices, supply chain improvements etc. and will be communicated to the public.

The study is based on extensive data collection for Sprout's activities and their sources materials, packaging and transport. Specific data has been collected for energy, fuels and water consumption and waste and wastewater production for the assembly site of Sprout makeup liners in Poland.

Collected data has been coupled with life cycle datasets from the database ecoinvent v3.7. In some cases "proxy" datasets have been used because no datasets were available for specific processes and materials in Sprout's value chain. This is specifically the case for (1) the flower seeds, where sunflower has been used as a proxy dataset for wildflowers, (2) for the hydroxypropyl methylcellulose (HPMC) capsule, where carboxymethylcellulose has been used as a proxy dataset for HPMC, (3) the wooden casing of the pencil, where spruce wood has been used as a proxy dataset for cedar wood, (4) and for the makeup formula ingredients, where the specific ingredients have been represented by vegetable oil, glycerine, feldspar and titanium dioxide. Specific details and reasoning for the use of proxy datasets are described in section 6. The use of proxy datasets increases the uncertainty in the results. The uncertainty must be taken into account when using the LCA results. The processes that occur after delivery of the Sprout makeup pencil to the customer (downstream processes) are based on scenarios. These scenarios also introduce uncertainty in the results. The downstream processes have been assessed in a sensitivity analysis to increase the confidence in the results.

4 SCOPE OF THE LCA

4.1 DELIVERABLES

This LCA of the Sprout makeup liner includes both life cycle inventory (LCI) analysis and life cycle impact assessment (LCIA).

LCI analysis is the process of accounting for all the input and output flows of the Sprout makeup liner's product system. Such flows include inputs of water, energy, and raw materials, and releases to air, land, and water. The LCI analysis requires extensive data collection for the product system and access to an LCI database. The LCI database is typically accessed through an LCA software.

LCIA is the process of translating the input and output flows from the LCI to *environmental impacts*. The LCIA is typically carried out in the LCA software using an *LCIA method*.

This LCA of the Sprout makeup liner is performed using the software SimaPro version 9.2 (PRé Consultants, 2021) with the implemented LCI database; ecoinvent version 3.7, system model APOS (Weidema et al., 2013).

The LCIA method used is the ReCiPe 2016, midpoint, hierarchical method. The climate change impact category has been replaced by IPCC 2013 GWP 100a incl. CO2 uptake, since this method is more descriptive of CO2 and carbon related impacts. The list of assessed impact categories and related indicators can be seen in Table 26.

4.2 FUNCTIONAL UNIT AND COMPOSITION

This LCA analyzes an average Sprout makeup liner (functional unit). Sprout makeup liners differ only in the makeup formula, whereas the remaining liner parts are identical. The current range of makeup includes the following seven formulas; black, beige, brown, dark brown, light brown, blue and grey. A simple average of the seven makeup formulas has been performed to obtain an average Sprout liner. The composition of the average Sprout makeup liner (functional unit) is shown in Table 1.

TABLE 1: COMPOSITION OF AVERAGE SPROUT LINER (FUNCTIONAL UNIT)

COMPONENT	MG (MILLIGRAM)	% OF TOTAL WEIGHT	DESCRIPTION
Makeup formula	1550	39%	Makeup formula ingredients sourced from various locations in the world. Assembled with wooden casing and lid in Germany before assembly with remaining components of the Sprout makeup liner in Poland.
Wooden casing	1170	29%	Pencil casing of cedar wood sourced in California and processed in Indonesia. Assembled with makeup formula and lid in Germany before assembly with remaining components of the Sprout makeup liner in Poland.
Lid	1000	25%	Lid of biobased (sugarcane) polyethylene sourced and produced in Brazil. Assembled with wooden casing and makeup formula in Germany before assembly with remaining components of the Sprout makeup liner in Poland.
Wood flour	130	3%	Waste product from sawmill in Denmark. Used for filling in the capsule with the wildflower seeds. Assembled with Sprout makeup liner in Poland.
Capsule	105,5	3%	Capsule of hydroxypropyl methylcellulose (HPMC) sourced in Colombia. Used for holding the wildflower seeds and wood flour at the end of the makeup liner. Assembled with Sprout makeup liner in Poland.
Glue	24,05	1%	Clear school glue sourced in China. Used for attaching the HPMC capsule at the end of the makeup liner. Assembled with Sprout makeup liner in Poland.
Seeds	7	0%	Wildflower seeds sourced in the Netherlands. Encapsulated at the end of the makeup liner and intended for planting after the makeup liner is used. Assembled with Sprout makeup liner in Poland.
Total	**3987**	**100%**	

5 SYSTEM BOUNDARY

The system boundaries of the LCA are described in the flow diagram in Figure 1. The figure shows the included processes in the LCA of the Sprout makeup liner. To each process in the life cycle there are inputs of fuels, energy, materials and water. From each process there are also emissions to air, soil and water. These are not indicated for each process in the diagram. Packaging materials and transport for components sent to the assembly site in Poland are also included. So is the transport from the assembly site to the customer.

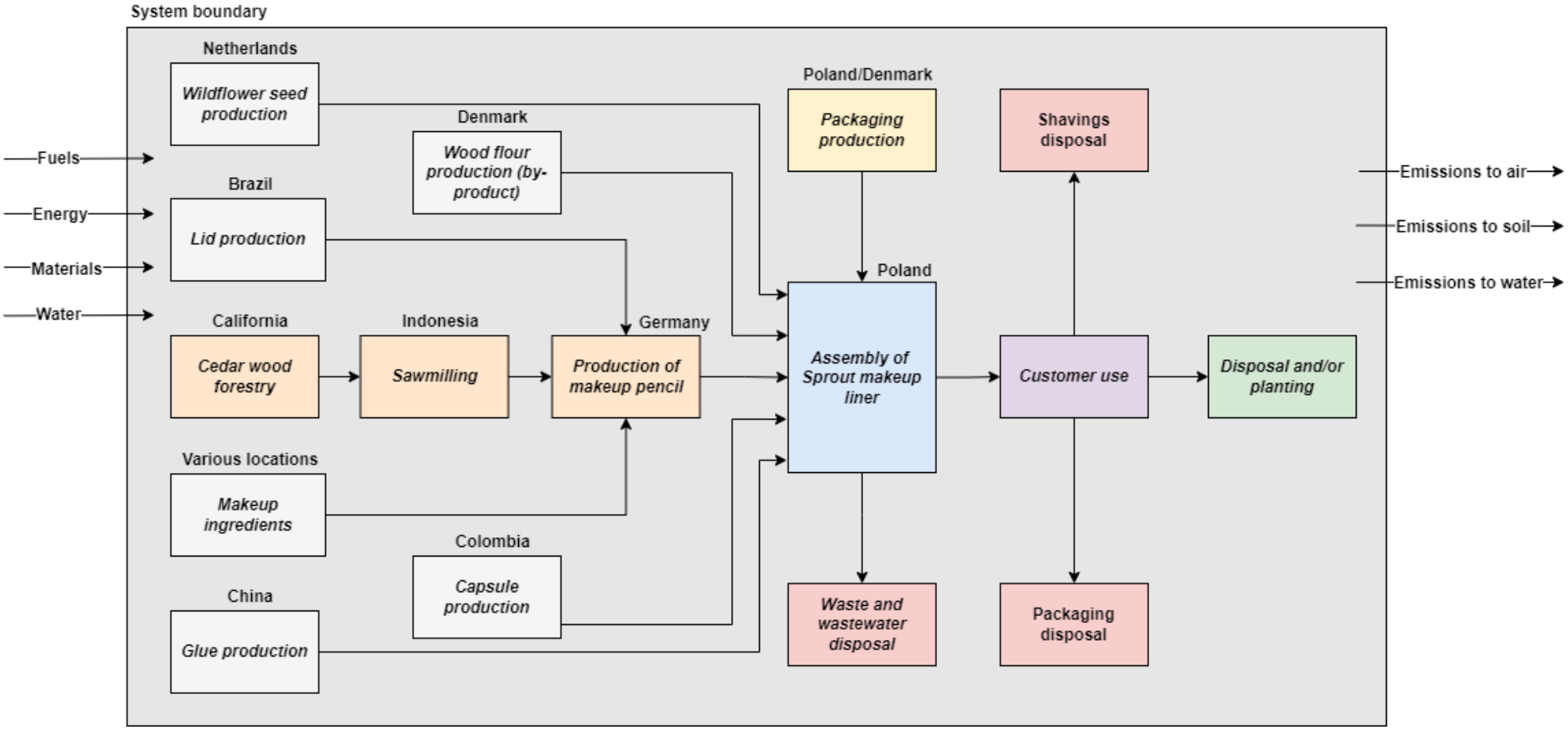

FIGURE 1: SYSTEM BOUNDARIES OF THE LCA

6 LIFE CYCLE INVENTORY ANALYSIS (LCI)

6.1 PRODUCTION OF PENCIL COMPONENTS

The pencil including wooden casing and makeup formula is produced in Germany and assembled with the lid. The wood is sourced from a sawmill in Indonesia which sources the raw wood from California. The ingredients for the makeup formula are sourced from various parts of the world. The lid is sourced from Brazil, where the raw material for the lid – sugarcane – is also sourced.

6.1.1 WOODEN CASING

The wooden casing consists of 100% PEFC certified cedar wood from California. The harvested wood is transported to Indonesia for sawing, drying and planing. The wood is then transported to Germany where the wooden casing is milled, assembled with makeup formula and the tip is shaved.

For the wood harvest in California an ecoinvent dataset for spruce harvest in Sweden (SE) has been adapted. There is no dataset available for cedar wood and spruce has been used as a "proxy" process since both cedar and spruce are softwood species. The adaptations are described in Table 2.

Transport from California to Indonesia has been estimated using www.ecotransit.org, which assesses the most likely route and distances when using ship as the main transport mode. Truck transport from harvest location to harbor in California, ship from harbor in California to harbor in Indonesia, and truck from harbor in Indonesia to sawmill is included. Location of harvest in California and sawmill in Indonesia are unknown, and a central location in each state or country is used (default location when selecting California or Indonesia in www.ecotransit.org). Packaging is only included for tier 1 suppliers in this LCA, meaning that it is not included for this step.

TABLE 2: UNIT PROCESS 1 FOR WOOD HARVEST IN CALIFORNIA

Unit process 1: Wood harvest California				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wood harvest California	4,65E-06	m3	Sawlog and veneer log, softwood, measured as solid wood under bark {SE}| softwood forestry, spruce, sustainable forest management | APOS, U	ecoinvent dataset not available for US (California). Dataset for SE geography adapted to US (California) geography by exchanging SE or RER datasets with US or RoW datasets.
Transport	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Truck California	1,17E-03	tkm	Transport, freight, lorry, unspecified {RoW}| market for transport, freight, lorry, unspecified | APOS, U	Transport from California to Indonesia, 1st leg. Routes and distances estimated with www.ecotransit.org.
Global shipping	4,81E-02	tkm	transport, freight, sea, bulk carrier for dry goods {GLO}| market for transport, freight, sea, bulk carrier for dry goods | APOS, U	Transport from California to Indonesia, 2nd leg. Routes and distances estimated with www.ecotransit.org.
Truck Indonesia	5,04E-04	tkm	Transport, freight, lorry, unspecified {RoW}| market for transport, freight, lorry, unspecified | APOS, U	Transport from California to Indonesia, 3rd leg. Routes and distances estimated with www.ecotransit.org.

For the sawmill processes in Indonesia including sawing, drying and planing four ecoinvent datasets for these processes in Switzerland (CH) have been adapted.

The sawing process is represented by an ecoinvent dataset for sawing of softwood in Switzerland (CH) and has been adapted to fit Indonesia as described in Table 3.

TABLE 3: UNIT PROCESS 2 FOR WOOD SAWING IN INDONESIA

Unit process 2: Wood sawing Indonesia				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wood sawing Indonesia	3,19E-06	m3	Sawnwood, softwood, raw {CH}| sawing, softwood | APOS, U	ecoinvent dataset not available for Indonesia (ID). Dataset for CH geography adapted to ID geography by exchanging CH or RER datasets with ID or RoW datasets. See specific adaptions in comments below. The sawlog input in the dataset has been exchanged with unit process 1 for wood harvest in California.
Transport	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
No transport at this step				

The drying process is represented by two ecoinvent datasets – one for air-drying (20% air dried) and one for kiln drying (80% kiln dried) based on the Swiss market share of these two drying technologies. The wood is assumed dried to 20% moisture content. The datasets and their adaptions are shown in Table 4 (air-drying) and Table 5 (kiln-drying).

TABLE 4: UNIT PROCESS 3A FOR WOOD AIR-DRYING IN INDONESIA

Unit process 3a: Wood air drying Indonesia				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Air drying of wood	6,13E-07	m3	Sawnwood, lath, softwood, raw, dried (u=20%) {CH}| lath, softwood, raw, air drying to u=20% | APOS, U	ecoinvent dataset not available for Indonesia (ID). Dataset for CH geography adapted to ID geography only by exchanging the sawnwood input in the dataset with unit process 2 for wood sawn in Indonesia.
Transport	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
No transport at this step				

TABLE 5: UNIT PROCESS 3B FOR WOOD KILN-DRYING IN INDONESIA

Unit process 3b: Wood kiln drying Indonesia				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Kiln-dried wood lath Indonesia	2,45E-06	m3	Sawnwood, lath, softwood, raw, dried (u=20%) {CH}| lath, softwood, raw, kiln drying to u=20% | APOS, U	ecoinvent dataset not available for Indonesia (ID). Dataset for CH geography adapted to ID geography by exchanging CH or RER datasets with ID or RoW datasets. The sawnwood input in the dataset has been exchanged with unit process 2 for wood sawn in Indonesia.
Transport	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
No transport at this step				

The planing process is represented by an ecoinvent dataset for planing of laths of softwood in Switzerland (CH) and has been adapted to fit Indonesia as described in Table 6. After planing the wood is sent to the manufacturer of the makeup liners in Germany.

Transport from Indonesia to Germany has been estimated using www.ecotransit.org, which assesses the most likely route and distances when using ship as the main transport mode. Truck transport from sawmill to harbor in Indonesia, ship from harbor in Indonesia to harbor in Germany, and truck from harbor in Germany to production site is included. Location of sawmill in Indonesia is unknown, and a central location in the country is used (default location when selecting Indonesia in www.ecotransit.org). The location of the manufacturer of the makeup liner in Germany is known and the specific location has been used. Packaging is only included for tier 1 suppliers in this LCA, meaning that it is not included for this step.

TABLE 6: UNIT PROCESS 4 FOR WOOD PLANING IN INDONESIA

Unit process 4: Wood planing Indonesia				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Planing of dried wood Indonesia	2,78E-06	m3	Sawnwood, lath, softwood, dried (u=20%), planed {CH}| planing, lath, softwood, u=20% | APOS, U	ecoinvent dataset not available for Indonesia (ID). Dataset for CH geography adapted to ID geography by exchanging CH or RER datasets with ID or RoW datasets. The inputs of air-dried and kiln-dried wood have been exchanged with unit process 3a and 3b for air-drying and kiln-drying of wood in Indonesia.
Transport	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Truck Indonesia	2,12E-04	tkm	Transport, freight, lorry, unspecified {GLO}| market group for transport, freight, lorry, unspecified | APOS, U	Transport from Indonesia to Germany, 1st leg. Routes and distances estimated with www.ecotransit.org.
Global shipping	1,76E-02	tkm	transport, freight, sea, bulk carrier for dry goods {GLO}| market for transport, freight, sea, bulk carrier for dry goods | APOS, U	Transport from Indonesia to Germany, 2nd leg. Routes and distances estimated with www.ecotransit.org.
Truck Europe	1,24E-03	tkm	Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | APOS, U	Transport from Indonesia to Germany, 3rd leg. Routes and distances estimated with www.ecotransit.org.

For the milling and shaving of the wooden casing in Germany there was no data available for the energy use and waste and no ecoinvent dataset available either. The same ecoinvent dataset as for wood planing was adapted and used as a "proxy" process for milling. The adaptations are described in

Table 7. Aside from the waste from milling, waste from shaving the pencil was added. In reality, shaving does not happen before assembly with the makeup formula, but for simplicity, the shaving waste was added at this step. It was assumed that the factory shaving of the pencil only removes wood, although in reality it will also remove a minor amount of the makeup formula. The volume and mass of wood removed during shaving was obtained by the following steps:

- Calculating the volume of the remaining cone on top of the pencil after shaving with 7 mm diameter and 10 mm height.
  The formula: Volume of cone = 1/3 · height · π · r^2 = 1/3 · 1 cm · π · (0,7/2 cm)^2 = 0,128 cm^3
- Calculating the volume of the cylinder "on top" of the pencil before shaving with 7 mm diameter and 10 mm height. The formula: Volume of cylinder = height · π · r^2 = 1 cm · π · (0,7/2 cm)^2 = 0,385 cm^3
- Subtracting the volume of the cone from the volume of the cylinder: vol. cylinder – vol. cone = 0,385 cm^3 - 0,128 cm^3 = 0,257 cm^3

- The mass of the shavings were estimated to be 0,132 g using a density of 516 kg/m^3 of the wooden casing.

Transport from the manufacturer in Germany to the Sprout makeup liner assembly in Poland is included in the makeup liner assembly in Germany – see unit process 9 in Table 12.

TABLE 7: UNIT PROCESS 5 FOR MILLING AND SHAVING OF WOODEN CASING IN GERMANY

Unit process 5: Wood milling and shaving Germany				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Milling and shaving of wooden case	2,78E-06	m3	Sawnwood, lath, softwood, dried (u=20%), planed {CH}| planing, lath, softwood, u=20% | APOS, U	ecoinvent dataset not available for Germany (DE). Dataset for CH geography adapted to DE geography by exchanging CH datasets with DE or Europe without Switzerland datasets. Extra wood shaving waste has been added for the amount of removed wood when shaving the pencil. The input of planed wood has been exchanged with unit process 4 for dried and planed wood from Indonesia.
Transport	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
No transport at this step				

6.1.2 MAKEUP FORMULA

The makeup formulas for the Sprout liner are produced in Germany. Sprout makeup liners differ only in the makeup formula, whereas the remaining parts of the liner are identical. The current range of makeup includes the following seven formulas; black, beige, brown, dark brown, light brown, blue and grey. A simple average of the seven makeup formulas has been performed to obtain an average makeup formula for the purpose of this LCA.

The single formulas each contain between 12 and 15 different ingredients, but altogether the formulas and the average formula contain 27 ingredients. The makeup manufacturer has provided the geographical sourcing area for each ingredient. The 27 raw materials are sourced from the following areas: France, India, Brazil, Mexico, United States, United Kingdom, Germany, “United States/Mexico”, “Latin America”, “Indonesia/Philippines”, “Worldwide except United States”, “France/United States”, and “Europe/United States”. The sourcing areas for each of the 27 ingredients are not presented here.

For the areas provided by the manufacturer that are not a single country a conservative approach has been used. “United States/Mexico” is assumed Mexico, “Latin America” is assumed Brazil, “Indonesia/Philippines” is assumed Philippines, “Worldwide except United States” is assumed India, “France/United States” is assumed United States, and “Europe/United States” is assumed United States.

In Table 8 the ingredients are divided into the following categories; triglycerides, oil- and wax-based ingredients, minerals and pigments. The % of each ingredient category in the average makeup formula is also shown in Table 8.

TABLE 8: COMPOSITION OF AVERAGE MAKEUP FORMULA

INGREDIENT CATEGORY	INGREDIENTS IN CATEGORY*	SOURCING AREAS	% OF TOTAL WEIGHT
Triglycerides	Triglycerides, Caprylic/capric triglyceride	France, Philippines	42
Oil- and wax-based ingredients	Castor oil cold pressed, Hydrogenated castor oil, Orbignya olefeira seed oil, Carnauba wax, Candelilla wax, Tocopheryl acetate, Tocopherol	India, Brazil, Mexico	34
Minerals	Mica	Brazil	7
Pigments	Ultramarine, titanium dioxide, iron oxide, ferric ammonium ferrocyanice	United States, United Kingdom, Germany, India	18
Total			100%

* Some of the ingredients are grouped together here, i.e. there are different types of iron oxide, candelilla wax and other ingredients.

For the makeup formula ingredients there is generally a lack of datasets in ecoinvent. Therefore, each ingredient category has been matched with a “proxy” dataset in ecoinvent. For triglycerides an ecoinvent dataset for glycerin has been used. For Oil-and wax-based ingredients an ecoinvent dataset for vegetable oil has been used. For minerals an ecoinvent dataset for Feldspar has been used. Finally, for pigments an ecoinvent dataset for titanium dioxide has been used. The use of proxy datasets in the makeup formula increases the uncertainty in the results. Nonetheless, it is considered a decent estimate of the magnitude of the environmental impact. The datasets used and adaptations are shown in Table 9.

Transport from the makeup ingredient sourcing area to the manufacturer in Germany has been estimated using www.ecotransit.org, which assesses the most likely route and distances. For overseas sourcing ship has been used as the main transport mode. For European sourcing truck has been used as the main transport mode. For overseas sourcing both truck transport from the sourcing area to harbor in the sourcing area, ship from harbor in the sourcing area to harbor in Europe, and truck from harbor in Europe to the makeup liner manufacturer in Germany are included. Location of production facilities in the sourcing areas are unknown, and a central location in the sourcing areas are used (default locations when

selecting the sourcing areas in www.ecotransit.org). Packaging is only included for tier 1 suppliers in this LCA, meaning that it is not included for this step.

TABLE 9: UNIT PROCESS 6 FOR MAKEUP FORMULA INGREDIENTS

Unit process 6: Makeup formula				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Oil and wax-based ingredients	5,30E-04	kg	Vegetable oil, refined {GLO}| market for | APOS, U	Default transport removed from this process
Mineral ingredients	1,02E-04	kg	Feldspar {RoW}| production | APOS, U	Default transport removed from this process
Pigments	2,74E-04	kg	Titanium dioxide {RoW}| market for | APOS, U	Default transport removed from this process
Glycerine ingredients Europe	2,69E-04	kg	Glycerine {RER}| market for glycerine | APOS, U	Default transport removed from this process
Glycerine ingredients RoW	3,75E-04	kg	Glycerine {RoW}| market for glycerine | APOS, U	Default transport removed from this process
Transport	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Truck RoW	1,95E-03	tkm	Transport, freight, lorry 16-32 metric ton, EURO5 {RoW}| transport, freight, lorry 16-32 metric ton, EURO5 | APOS, U	Transport truck on location outside of Europe. Routes and distances for each ingredient estimated with www.ecotransit.org and summed up.
Ferry Global	4,28E-05	tkm	transport, freight, sea, ferry {GLO}| market for transport, freight, sea, ferry | APOS, U	Transport ferry on location outside of Europe. Routes and distances for each ingredient estimated with www.ecotransit.org and summed up.
Global shipping	1,26E-02	tkm	transport, freight, sea, container ship {GLO}| transport, freight, sea, container ship | APOS, U	Transport global shipping. Routes and distances for each ingredient estimated with www.ecotransit.org and summed up.
Truck Europe	1,10E-03	tkm	Transport, freight, lorry 16-32 metric ton, EURO5 {RER}| transport, freight, lorry 16-32 metric ton, EURO5 | APOS, U	Transport truck in Europe. Routes and distances for each ingredient estimated with www.ecotransit.org and summed up.

6.1.3 LID

The lid for the makeup liner consists of bio-based PE made from sugarcane. The sugarcane is sourced in Brazil and the lid is produced in Brazil. The lid is transported to Germany for assembly with the makeup liner.

For the bio-based PE production in Brazil results from the supplier's own LCA were used. The results are available on the manufacturers website (accessed November 7, 2022) and are summarized in Table 10 for the amount of bio-based PE used for one lid (1,0299 g including manufacturing waste).

TABLE 10: UNIT PROCESS 7 FOR BIOBASED PE PRODUCTION IN BRAZIL (BASED ON RESULTS OF THE SUPPLIER'S LCA OF BIO-BASED PE.)

SUPPLIER LCA RESULTS (FOR 1,0299 G BIOBASED PE)			SPROUT LCA RESULTS (FOR 1,0299 G BIOBASED PE)			CONVERSION
Impact category supplier LCA	Unit	Value	Impact category Sprout LCA	Unit	Value	
Climate Change	kg CO2 eq	1,2E-03	Climate Change - fossil	kg CO2 eq	1,2E-03	No conversion
Carbon Uptake	kg CO2 eq	-3,2E-03	Climate Change - CO2 uptake	kg CO2 eq	-3,2E-03	No conversion
Land Use Change	kg CO2 eq	-1,1E-03	Climate Change - land use	kg CO2 eq	-1,1E-03	No conversion
Ozone Depletion	kg CFC-11 eq	4,2E-08	Stratospheric ozone depletion	kg CFC-11 eq	4,2E-08	No conversion
Resource Depletion, water	m3	5,1E-05	Water consumption	m3	5,1E-05	No conversion
Resource Consumption	kg Sb eq	-1,8E-06	Mineral resource scarcity	kg Cu eq	-1,0E-06	5,72E-01 kg Cu eq/kg Sb
Eutrophication	kg PO4--- eq	1,3E-05	Freshwater eutrophication	kg P eq	4,3E-06	3,30E-01 kg P eq/kg PO4
No results in supplier LCA		-	Fossil resource consumption	kg oil eq	-	No results in supplier LCA
No results in supplier LCA		-	Marine eutrophication	kg N eq	-	No results in supplier LCA
No results in supplier LCA		-	Climate change - biogenic	kg CO2 eq	-	No results in supplier LCA

For the production of the lid from bio-based PE raw material in Brazil an ecoinvent dataset for blow moulding in a RoW geography has been adapted as described in Table 11. The raw material has been changed from normal PE to bio-based PE as described earlier (see unit process 7 in Table 10) and the amount of PE waste defined in the ecoinvent dataset for blow moulding. The waste is treated through incineration and the CO_2 emissions from incineration have been changed to biogenic emissions since the bio-based PE only contains carbon taken up by the sugarcane it is made from.

Transport from Brazil to Germany has been estimated using www.ecotransit.org, which assesses the most likely route and distances when using ship as the main transport mode. Truck transport from production facility to harbor in Brazil, ship from harbor in Brazil to harbor in Germany, and truck from harbor in Germany to the makeup liner manufacturer in Germany are included. Location of production facility in Brazil is unknown, and a central location in Brazil is used (default location when selecting Brazil in www.ecotransit.org). The location of the manufacturer of the makeup liner in Germany is known and the specific location has been used. Packaging is only included for tier 1 suppliers in this LCA, meaning that it is not included for this step.

TABLE 11: UNIT PROCESS 8 FOR PRODUCTION OF BIO-BASED PE LID BY BLOW MOULDING IN BRAZIL

Unit process 8: Bio-based PE lid production				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Blow moulding of lid	1,00E-03	kg	PE Lid, Blow moulding {RoW}| blow moulding | APOS, U	ecoinvent dataset not available for Brazil (BR). Dataset for RoW geography adapted to BR geography by exchanging RoW of other country datasets with BR datasets. The CO2 emissions from incineration of plastic waste are changed from fossil CO2 to biogenic CO2, since the PE is bio-based.
Bio-based PE input incl. waste	1,03E-03	kg	-	Not an ecoinvent dataset. Based on supplier LCA. See unit process 7.
Transport	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Truck Brazil	1,65E-03	tkm	Transport, freight, lorry, unspecified {GLO}| market group for transport, freight, lorry, unspecified | APOS, U	Transport from Brazil to Germany, 1st leg. Routes and distances estimated with www.ecotransit.org.
Global shipping	1,13E-02	tkm	transport, freight, sea, container ship {GLO}| transport, freight, sea, container ship | APOS, U	Transport from Brazil to Germany, 2nd leg. Routes and distances estimated with www.ecotransit.org.
Truck Europe	6,36E-04	tkm	Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | APOS, U	Transport from Brazil to Germany, 3rd leg. Routes and distances estimated with www.ecotransit.org.

6.1.4 ASSEMBLY OF PENCIL IN GERMANY

The wooden casing, makeup formula and lid are assembled in Germany before being packaged and transported by truck to the Sprout liner facility in Poland. There is no knowledge about the assembly process in Germany and therefore it has not been included in this LCA. The only process included from the makeup liner production in Germany is the milling of the wooden casing shown in Table 7. The supplier that delivers the makeup liners to Sprout is a tier 1 supplier and therefore the packaging for this step is included. The liners are packaged in cardboard boxes weighing 1 kg per box and one box contains 5000 makeup liners. See unit process 9 in Table 12. This makeup liner only includes wooden casing, makeup formula and lid. It does not include capsule, flower seeds etc, which is added at a later stage in Poland.

Transport from Germany to Poland has been estimated using www.ecotransit.org, which assesses the most likely route and distances when using truck as the transport mode. Location of production facility in Germany and Sprout makeup liner facility in Poland are known, and the exact locations are used for estimation of the distance. The transported mass includes the weight of the makeup liner and the weight of packaging assigned to 1 pencil.

TABLE 12: UNIT PROCESS 9 FOR MAKEUP LINER ASSEMBLY IN GERMANY

Unit process 9: Makeup liner assembly Germany				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Makeup formula	1,55E-03	kg	-	See unit process 6
Wood casing	1,17E-03	kg	-	See unit process 5
Lid	1,00E-03	kg	-	See unit process 8
Transport and packaging	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Cardboard packaging	0,0002	kg	Corrugated board box {RER}| market for corrugated board box | APOS, U	
Truck Europe	0,0030	tkm	Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | APOS, U	Transport Germany to Poland by truck. Routes and distances estimated with www.ecotransit.org.

6.2 PRODUCTION OF OTHER COMPONENTS

6.2.1 CAPSULE

The capsule which contains the seeds at the end of the Sprout makeup liner is made of hydroxypropyl methylcellulose (HPMC) and it is produced in Colombia. The raw material is also assumed to be from Colombia. It is distributed through Germany before being transported to the Sprout makeup liner facility in Poland.

There is no ecoinvent dataset available for the production of HPMC, thus a dataset for the production of carboxymethylcellulose has been used as a proxy for the raw material. Carboxymethylcellulose is used as a proxy because both materials are cellulose-based. The use of proxy datasets increases the uncertainty in the results. The dataset for carboxymethylcellulose production in Europe (RER) has been adapted. The adaptations are described in Table 13.

TABLE 13: UNIT PROCESS 10 FOR THE PRODUCTION OF HYDROXYMETHYLCELLULOSE (HPMC) IN COLOMBIA

Unit process 10: HPMC production				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
HPMC	1,09E-04	kg	Carboxymethyl cellulose, powder {RER}| production | APOS, U	ecoinvent dataset not available for CO (Colombia). Dataset for RER geography adapted to CO geography by exchanging RER datasets with CO, RoW or GLO datasets.
Transport and packaging	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
No transport at this step				

The production of the HPMC capsule takes place in Colombia and is represented by an ecoinvent dataset for sawing of softwood in for blow moulding in a Rest of World (RoW) geography. The dataset has been adapted to fit Colombia as described in Table 14.

Transport from Colombia through Germany to Poland has been estimated using www.ecotransit.org, which assesses the most likely route and distances when using ship as the main transport mode. Truck transport from production facility in Colombia, ship from harbor in Colombia to harbor in Europe, truck from harbor in Europe to distribution site in Germany and truck from distribution site to the Sprout makeup liner facility in Poland is included. Location of production site in Colombia is unknown, and a central location in the country is used (default location when selecting Colombia in www.ecotransit.org). The location of the distribution site in Germany and the Sprout makeup liner facility in Poland are known and the specific locations have been used.

TABLE 14 UNIT PROCESS 11 FOR THE PRODUCTION OF HPMC CAPSULE BY BLOW MOULDING IN COLOMBIA

Unit process 11: HPMC capsule production				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Blow moulding of capsule	1,06E-04	kg	Blow moulding {RoW}| blow moulding | APOS, U	ecoinvent dataset not available for CO (Colombia). Dataset for RoW geography adapted to CO geography by exchanging RoW datasets with CO datasets.
HPMC input incl. waste	1,09E-04	kg	-	See unit process 10
Transport and packaging	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Cardboard box	2,00E-05	kg	Corrugated board box {RoW}| market for corrugated board box | APOS, U	Cardboard box packaging. The HPMC capsules are packaged in a 450 g plastic bag and a 2 kg cardboard box containing 100.000 capsules.
Plastic bag	4,50E-06	kg	Packaging film, low density polyethylene {RoW}| production | APOS, U	Plastic bag packaging. The HPMC capsules are packaged in a 450 g plastic bag and a 2 kg cardboard box containing 100.000 capsules.
Truck Colombia	5,95E-05	tkm	Transport, freight, lorry, unspecified {RoW}| market for transport, freight, lorry, unspecified | APOS, U	Transport from Colombia to Poland, 1st leg. Routes and distances estimated with www.ecotransit.org.
Global shipping	1,50E-03	tkm	transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | APOS, U	Transport from Colombia to Poland, 2nd leg. Routes and distances estimated with www.ecotransit.org.
Truck Europe	1,51E-04	tkm	Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | APOS, U	Transport from Colombia to Poland, 3rd leg. Routes and distances estimated with www.ecotransit.org.

6.2.2 SEEDS

The wildflower seeds contained in the capsule at the end of the Sprout makeup liner are produced in the Netherlands and transported to the Sprout makeup liner facility in Poland.

There is no ecoinvent dataset available for the production of wildflower seeds, thus a dataset for the production of sunflower seeds has been used as a proxy. Sunflower seed is the only flower seed available in the ecoinvent database. The use of proxy datasets increases the uncertainty in the results. The dataset for sunflower seed production France (FR) has not been adapted to represent the Netherlands since the conditions are assumed similar in the two countries. The dataset is described in Table 15Table 13.

Transport from the Netherlands to Poland has been estimated using www.ecotransit.org, which assesses the most likely route and distances when using truck as the main transport mode. Location of production site in the Netherlands is unknown, and a central location in the country is used (default location when selecting the Netherlands in www.ecotransit.org). The location of the Sprout makeup liner facility in Poland is known and the specific location has been used.

TABLE 15: UNIT PROCESS 12 FOR THE PRODUCTION OF WILFLOWER SEEDS IN THE NETHERLANDS

Unit process 12: Wildflower seeds production				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wildflowers Netherlands	7,00E-06	kg	Sunflower seed {FR}| sunflower production | APOS, U	Dataset for sunflower seed production in France (FR) has been used as proxy for wildflower production in Netherlands.
Transport and packaging	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Cardboard box	1,59E-07	kg	Corrugated board box {RER}| market for corrugated board box | APOS, U	Cardboard box packaging. The seeds are packaged in plastic bags inside a cardboard box. 88 g plastic and 500 g cardboard is used per 22 kg seeds.
Plastic bag	2,80E-08	kg	Packaging film, low density polyethylene {RER}| production | APOS, U	Plastic bag packaging. The seeds are packaged in plastic bags inside a cardboard box. 88 g plastic and 500 g cardboard is used per 22 kg seeds.
Truck Europe	7,85E-06	tkm	Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | APOS, U	Transport from Netherlands to Poland. Routes and distances estimated with www.ecotransit.org.

6.2.3 WOOD FLOUR

The wood flour contained together with the wildflower seeds in the capsule at the end of the Sprout makeup liner is produced as a by-product at Sawmills in Denmark. It is transported from Denmark to the Sprout makeup liner facility in Poland.

There is no ecoinvent dataset available for the production of “wood flour”, thus a dataset for sawdust has been used as a proxy. This is considered a good proxy as both materials are byproducts of sawmills. The dataset for sawdust in a Rest of World (RoW) geography has been adapted to represent Denmark as described in Transport from the Denmark to Poland has been estimated using www.ecotransit.org, which assesses the most likely route and distances when using truck as the main transport mode. The locations of the production site in Denmark and the Sprout makeup liner facility in Poland are known and the specific locations have been used.

Table 16.

Transport from the Denmark to Poland has been estimated using www.ecotransit.org, which assesses the most likely route and distances when using truck as the main transport mode. The locations of the production site in Denmark and the Sprout makeup liner facility in Poland are known and the specific locations have been used.

TABLE 16: UNIT PROCESS 13 FOR THE PRODUCTION OF WOOD FLOUR IN DENMARK

Unit process 13: Wood flour production				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wood flour	1,30E-04	kg	sawdust, wet, measured as dry mass {RoW}| suction, sawdust | APOS, U	ecoinvent dataset not available for DK (Denmark). Dataset for RoW geography adapted to DK geography by exchanging RoW datasets with DK, Europe (RER) or Europe without Switzerland datasets. See specific adaptions in comments below.
Transport and packaging	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Paper sack packaging	2,17E-06	kg	paper sack {RER}| market for paper sack | APOS, U	Paper sack packaging. The wood flour is packaged in 250 g paper bags containing 15 kg of wood flour.
Truck Europe	1,43E-04	tkm	Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | APOS, U	Transport from Netherlands to Poland. Routes and distances estimated with www.ecotransit.org.

6.2.4 GLUE

The glue that is used to attach the HPMC capsule to the end of the wooden casing of the makeup liner is produced in China. The glue is a clear school type glue, commonly used by children. It is distributed from China through Germany to the Sprout makeup liner facility in Poland.

There is no ecoinvent dataset available for the production of clear school glue, thus a dataset for the production of melamine urea formaldehyde (MUF) adhesive has been used as a proxy. Since MUF adhesive is a more technical adhesive used for wood board production it is considered a conservative representation of the clear school glue. The use of proxy datasets generally increases the uncertainty in the results. The dataset for MUF adhesive globally (GLO) has been adapted to represent China as described in Table 17.

Transport from China through Germany to Poland has been estimated using www.ecotransit.org, which assesses the most likely route and distances when using ship as the main transport mode. Truck transport from production facility in China to harbor in China, ship from harbor in China to harbor in Europe, truck from harbor in Europe to distribution site in Germany and truck from distribution site to the Sprout makeup liner facility in Poland is included. Locations of production site in China and distribution site in Germany are unknown, and central locations in the countries are used (default locations when selecting China or Germany in www.ecotransit.org). The location of the Sprout makeup liner facility in Poland is known and the specific location has been used.

TABLE 17: UNIT PROCESS 14 FOR THE PRODUCTION OF GLUE IN CHINA

Unit process 14: Glue production				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Glue	2,41E-05	kg	melamine urea formaldehyde adhesive {GLO}| melamine urea formaldehyde adhesive production | APOS, U	Dataset for melamine urea formaldehyde adhesive globally (GLO) has been used as proxy for school glue production in China by exchanging GLO, RER or specific country datasets with China (CN) or RoW datasets.
Transport and packaging	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
PET for bottle packaging	4,16E-06	kg	Polyethylene terephthalate, granulate, bottle grade {GLO}| market for | APOS, U	Plastic bottle packaging - raw material. The glue is packaged in plastic bottles weighing 125 g with a glue content of 722 g and in cardboard boxes weighing 228 g containing 8 bottles of glue.
Blow moulding of PET bottle	4,16E-06	kg	Blow moulding {GLO}| market for | APOS, U	Plastic bottle packaging - blow moulding. The glue is packaged in plastic bottles weighing 125 g with a glue content of 722 g and in cardboard boxes weighing 228 g containing 8 bottles of glue.
Cardboard box packaging	9,48E-07	kg	Corrugated board box {RoW}| market for corrugated board box | APOS, U	Cardboard box packaging. The glue is packaged in plastic bottles weighing 125 g with a glue content of 722 g and in cardboard boxes weighing 228 g containing 8 bottles of glue.

Unit process 14: Glue production				
Truck China	4,89E-05	tkm	Transport, freight, lorry, unspecified {GLO}| market group for transport, freight, lorry, unspecified | APOS, U	Transport from China through Germany to Poland, 1st leg. Routes and distances estimated with www.ecotransit.org.
Global shipping	6,12E-04	tkm	transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | APOS, U	Transport from China through Germany to Poland, 2nd leg. Routes and distances estimated with www.ecotransit.org.
Truck Europe	3,02E-05	tkm	Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | APOS, U	Transport from China through Germany to Poland, 3rd leg. Routes and distances estimated with www.ecotransit.org.

6.3 ASSEMBLY OF SPROUT MAKEUP LINER

The sprout makeup liner is assembled at a production facility in Poland. The makeup liner without seeds and capsule is delivered to this facility and the capsule with seeds and wood flour is attached to the end of the Sprout makeup liner using glue. This process is to a large extent manual. The production facility consumes electricity, heat, water and diesel and produces wastewater, paper waste, biowaste and residual waste. Data for consumption and waste production for 1 year of production was obtained from the production facility and assigned to each pencil by dividing by the number of pencils produced. This attribution is a good estimate since the facility only produces Sprout pencils and makeup liners, and the production process is identical for these two product types at this step. The datasets used for the production facility are shown in Table 18.

TABLE 18: UNIT PROCESS 15 FOR ASSEMBLY OF SPROUT MAKEUP LINER IN POLAND

Unit process 15: Assembly of Sprout makeup				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Makeup liner	3,72E-03	kg	-	See unit process 9
Wildflower seeds	7,00E-06	kg	-	See unit process 12
Wood flour	1,30E-04	kg	-	See unit process 13
HPMC capsule	1,09E-04	kg	-	See unit process 11
Glue	2,41E-05	kg	-	See unit process 14
Auxiliary inputs	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Electricity Poland	9,65,E-04	kWh	Electricity, low voltage {PL}| market for | APOS, U	The amount of electricity consumed at the production facility was divided by the number of produced units in the production facility. 50% of the electricity comes from the facility's own solar panels. The remaining 50% comes from the Polish grid (average Polish mix).
Electricity from solar panels	9,65,E-04	kWh	Electricity, low voltage {PL}| electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | Cut-off, U	
Heat Poland	2,32E-03	kWh	Heat, district or industrial, natural gas {PL}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical | APOS, U	The amount of heat from natural gas consumed at the production facility was divided by the number of produced units in the production facility. According to ecoinvent two types of natural gas heating are available in Poland. The heat used at the production facility was assigned to the two heating systems by
Heat Poland	6,95E-03	kWh	Heat, district or industrial, natural gas {PL}| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical | APOS, U	

Unit process 15: Assembly of Sprout makeup				
				using the prevalence of these two types of heating systems in Poland according to ecoinvent.
Water	4,63E-05	ton	Tap water {Europe without Switzerland}| market for | APOS, U	The amount of water consumed at the production facility was divided by the number of produced units in the production facility.
Diesel	2,40E-04	tkm	Transport, freight, light commercial vehicle {Europe without Switzerland}| market for transport, freight, light commercial vehicle | APOS, U	The amount of diesel used at the production facility was converted to tkm driven in a light commercial vehicle by applying the fuel economy of the vehicle (0,4 kg/tkm) and the density of diesel (0,830 kg/L). The total amount of diesel used was divided by the number of produced units in the production facility.
Waste outputs	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wastewater	4,63E-05	m3	Wastewater, average {Europe without Switzerland}| market for wastewater, average | APOS, U	The amount of wastewater was assumed equal to the amount of water consumed at the facility since no water is used in the product. The wastewater produced at the production facility was divided by the number of produced units in the production facility.
Paper waste	6,76E-05	kg	Paper (waste treatment) {GLO}| recycling of paper | APOS, U	The paper waste produced at the production facility was divided by the number of produced units in the production facility.
Biowaste	1,56E-03	kg	Biowaste {PL}| treatment of biowaste by anaerobic digestion | APOS, U	The biowaste produced at the production facility was divided by the number of produced units in the production facility.
Residual waste	1,20E-03	kg	Municipal solid waste {PL}| market for municipal solid waste | APOS, U	The residual waste produced at the production facility was divided by the number of produced units in the production facility.

6.4 PACKAGING OF SPROUT MAKEUP LINER

The Sprout makeup liners come in three different packaging systems described in Table 19. The box for “gift box 2 pcs” and “gift box 3 pcs” is the same with the number of makeup liners being the only difference. In this LCA the “single box 1 pcs” is used as the default scenario. The other two packaging systems will be assessed in section 8.2.1. The datasets used for the packaging system are shown in

Table 20.

TABLE 19: SPROUT MAKEUP LINER PACKAGING SYSTEMS

	SINGLE BOX 1 PCS	GIFT BOX 2 PCS	GIFT BOX 3 PCS
No. of pencils in box	1	2	3
Box size	14,5 cm x 3 cm x 1,5 cm	16 cm x 8,5 cm x 2 cm	
Box weight	7	27	
Material	White and printed FSC MIX 70% carton		
Production site	Poland	Denmark	

TABLE 20: UNIT PROCESS 16 FOR THE PRODUCT PACKAGING OF THE SPROUT MAKEUP LINER

Unit process 16: Product packaging single box				
Material	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Carton box	7,00E-03	kg	solid bleached and unbleached board carton {CA-QC}| solid bleached and unbleached board carton production | APOS, U	ecoinvent dataset not available for PL (Poland). Dataset for Quebec, Canada (CA-QC) geography adapted to PL geography by exchanging CA-QC datasets with PL datasets.
Transport and packaging	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
No transport at this step				

6.5 TRANSPORT OF SPROUT MAKEUP LINER TO CUSTOMER

The Sprout makeup liner is sent to customers across the world. The default transport used in this LCA is based on an average delivery to the European market for all Sprout products. This includes the average distance from the Sprout production facility in Poland to one of our distribution partners' distribution centers in Europe and the average distance from these distribution centers to the most frequent customer cities around each

distribution center. On average that is a distance of 1720 km in total. Transport to the US is assessed in section 8.2.2. The dataset used for the transport to the customer is shown in Table 21.

TABLE 21: UNIT PROCESS 17 FOR TRANSPORT TO AN AVERAGE EUROPEAN CUSTOMER THROUGH DISTRIBUTION CENTERS

Unit process 17: Transport to customer Europe				
Transport	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Transport to customer in Europe	1,78E-02	Tkm	Transport, freight, lorry, unspecified {RER}| transport, freight, lorry, all sizes, EURO4 to generic market for | APOS, U	Transport of single box packaged makeup pencil in Europe through distribution center.

6.6 USE OF SPROUT MAKEUP LINER

The use phase of the Sprout pencil contains the following sub-processes;

- Disposal of the product packaging
- Shaving of the makeup liner and disposal of shavings
- Use of the makeup liner

After use the makeup is assumed to be washed off and discharged through the sewage and sent to wastewater treatment. The impact of wastewater treatment of the makeup residues is not accounted for in this LCA due to lack of methods to quantify it.

6.6.1 DISPOSAL OF PRODUCT PACKAGING

The disposal of the product packaging for Sprout makeup liners depend on the customer. Two disposal methods have been considered in this LCA – disposal with residual waste followed by incineration with energy recovery and source separation followed by recycling. An average scenario with 50% incineration and 50% recycling has been used as the default scenario. The datasets used for the packaging disposal are shown in Table 22.

TABLE 22: UNIT PROCESS 18 FOR THE DISPOSAL OF PRODUCT PACKAGING

Unit process 18: Product packaging single box				
Waste treatment	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Municipal incineration of carton box	3,5E-03	kg	Waste paperboard {RoW}| treatment of, municipal incineration | APOS, U	50% of the box weight (7 g)
Recycling of carton box	3,5E-03	kg	Paper (waste treatment) {GLO}| recycling of paper | APOS, U	50% of the box weight (7 g)

6.6.2 DISPOSAL OF SPROUT MAKEUP LINER SHAVINGS

During the use phase of the Sprout makeup liner 90% of the liner is assumed to be shaved off. Two disposal methods have been considered in this LCA – disposal with residual waste followed by incineration with energy recovery and disposal into the soil or pot where the makeup liner may eventually be planted. An average scenario with 50% incineration and 50% disposal into soil/plant pot has been used as the default scenario. The datasets used for the shaving disposal are shown in Table 23.

When the shavings are disposed of into soil the wood shavings will degrade over time. Some of the carbon in the wood will stay in the soil and some of the carbon will be released to the air as CO2. In this study 50% of the carbon is assumed to stay in the soil and 50% of the carbon is assumed to be released as CO2. This distribution was suggested in a study of compost use by the Australian Environmental Protection Agency. How long the carbon will stay in the soil is not taken into account (Department of Environment, Climate Change and Water NSW, 2011).

To calculate the amount of carbon in the wood a water content of 20% has been subtracted and 0,494 kg C/kg wood has been considered in line with the ecoinvent dataset used for wood (Unit process 1). The carbon stored in the soil is 50% of this carbon and the CO2 from the remaining 50% of the carbon is calculated by multiplying by the molar mass of CO2 over carbon: 44/12. The datasets used for disposal of makeup liner shavings is shown in Table 23.

TABLE 23: UNIT PROCESS 19 FOR THE DISPOSAL OF MAKEUP LINER SHAVINGS

Unit process 19: Disposal of makeup liner shavings				
Emissions to air	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wood disposal in soil, CO2 to air	3,97E-04	kg	Carbon dioxide, biogenic to air	50% of the shaved off 90% wood from the liner is disposed into the soil/pot. 49,4% of the dry weight of the wood is considered to be carbon. 50% carbon is released as CO2. Converted to CO2 by multiplying with 12/44.
Emissions to soil	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wood disposal in soil, carbon in soil	1,08E-04	kg	Carbon to soil	50% of the shaved off 90% wood from the liner is disposed into the soil/pot. 49,4% of the dry weight of the wood is considered to be carbon. 50% carbon is released into the soil.
Waste treatment	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Residual waste treatment	5,27E-04	kg	Waste wood, untreated {RoW}| treatment of waste wood, untreated, municipal incineration | APOS, U	50% of the shaved off 90% wood from the liner is disposed as residual waste.

6.7 DISPOSAL OF SPROUT MAKEUP LINER

The amount of makeup liner left at this stage is assumed to be 10% of the original size including the seeds, wood flour, capsule and lid. In this LCA a disposal scenario has been assessed as follows:

LINER PART	DISPOSAL METHOD 1 (50%)	DISPOSAL METHOD (50%)
Wood	Into the soil/pot (planted)	Residual waste (incineration)
Lid	Recycling	Residual waste (incineration)
Capsule	Into the soil/pot (planted)	Residual waste (incineration)
Seeds	Into the soil/pot (planted)	Disregarded
Wood flour	Disregarded	Disregarded

The datasets used for the disposal of the makeup liner after use are shown in Table 24.

TABLE 24: UNIT PROCESS 20 FOR THE DISPOSAL OF THE MAKEUP LINER AFTER USE

Unit process 20: Disposal of makeup liner after use				
Emissions to air	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wood disposal in soil, CO2 to air	5,29E-05	kg	Carbon dioxide, biogenic to air	50% of the remaining 10% of wood from the liner is disposed into the soil/pot. 49,4% of the dry weight of the wood is considered to be carbon. 50% carbon is released as CO2. Converted to CO2 by multiplying with 12/44.
Capsule disposal in soil, CO2 to air	4,27E-05	kg	Carbon dioxide, biogenic to air	50% of the capsule is disposed into the soil/pot. 44,4% of the dry weight of the capsule (cellulose) is considered to be carbon. 50% carbon is released as CO2. Converted to CO2 by multiplying with 12/44.
Emissions to soil	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wood disposal in soil, carbon in soil	1,44E-05	kg	Carbon to soil	50% of the remaining 10% of wood from the liner is disposed into the soil/pot. 49,4% of the dry weight of the wood is considered to be carbon. 50% carbon is released into the soil.
Capsule disposal in soil, carbon in soil	1,17E-05	kg	Carbon to soil	50% of the capsule is disposed into the soil/pot. 44,4% of the dry weight of the capsule (cellulose) is considered to be carbon. 50% carbon is released into the soil.
Waste treatment	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Wood incineration	5,85E-05	kg	Waste wood, untreated {RoW}| treatment of waste wood, untreated, municipal incineration | APOS, U	50% of the remaining 10% of wood from the liner is disposed as residual waste.
Lid recycling	5,00E-04	kg	Mixed plastics (waste treatment) {GLO}| recycling of mixed plastics | APOS, U	50% of the lid is recycled.
Lid incineration	5,00E-04	kg	Waste plastic, mixture {RoW}| treatment of waste plastic, mixture, municipal incineration | APOS, U	50% of the lid is disposed as residual waste.
Capsule incineration	2,28E-05	kg	Waste plastic, mixture {RoW}| treatment of waste plastic, mixture, municipal incineration | APOS, U	50% of the capsule is disposed as residual waste.

6.8 PLANT GROWTH AND DECAY

If the Sprout makeup liner is planted as intended wildflowers will grow from it. Nevertheless, the amount of growth is very variable and data for the water use and CO2 uptake is generally lacking. For this reason, this part of the Sprout makeup liner life cycle should be assessed further in the future. The results from this life cycle step are only indicative.

In line with ecoinvent datasets for seedlings the dry matter content in seedlings is 0,578 kg/kg wet mass, and the carbon content is 0,439 kg C/kg dry mass. Converting this to CO2 is used as an estimate for the amount of CO2 uptake by planting the wildflowers.

Furthermore, when the plants have sprouted, they will wither. Again, it is assumed that 50% of the carbon will stay in the soil and 50% of the carbon will be released as CO2 to the air. This is a rough estimate and should be assessed further in the future.

The planting is assumed to be undertaken without the use of fertilizers. The water use is disregarded. As a default 20 g of wet plant growth is considered in this LCA. Nevertheless, the results will be presented with and without the plant growth impact for full transparency. The dataset used for plant growth and decay is shown in Table 25.

TABLE 25: UNIT PROCESS 21 FOR THE PLANT GROWTH AND DECAY

Unit process 24: Plant growth and decay				
Natural resource	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Plant growth, CO2 uptake	1,85E-02	kg	Carbon dioxide, in air	20 g of wet plant growth. 0,578 kg dry matter/wet mass. 0,439 kg C/kg dry mass. Converted to CO2 by multiplying with 12/44.
Emissions to air	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Plant decay, CO2 to air	9,25E-03	kg	Carbon dioxide, biogenic to air	50% of the plant carbon is released as CO2. Converted to CO2 by multiplying with 12/44.
Emissions to soil	**Amount**	**Unit**	**ecoinvent dataset**	**Comments**
Plant decay, carbon in soil	2,54E-03	kg	Carbon to soil	50% of the plant carbon is released into the soil.

7 LIFE CYCLE IMPACT ASSESSMENT (LCIA)

7.1 LCIA METHOD

The LCIA results are calculated using the ReCiPe 2016, midpoint, hierarchical method. The climate change impact category has been replaced by IPCC 2013 GWP 100a incl. CO2 uptake, since this method is more descriptive of CO2 and carbon related impacts. The list of assessed impact categories and related indicators are listed in Table 26.

TABLE 26: IMPACT CATEGORIES ASSESSED IN THIS LCA

IMPACT CATEGORY	INDICATOR (EQ=EQUIVALENTS)	SOURCE
Climate change fossil	kg CO2 eq	IPCC 2013 GWP 100a incl. CO2 uptake
Climate change biogenic	kg CO2 eq	
Climate change CO2 uptake	kg CO2 eq	
Climate change land use and transformation	kg CO2 eq	
Stratospheric ozone depletion	kg CFC11 eq	ReCiPe 2016, midpoint, hierarchical method
Freshwater eutrophication	kg P eq	
Marine eutrophication	kg N eq	
Mineral resource scarcity	kg Cu eq	
Fossil resource scarcity	kg oil eq	
Water consumption	m3	

7.2 LCIA RESULTS

The life cycle impact assessment (LCIA) results are shown in Table 27. The total results per impact category as well as the impacts per component or life cycle stage are shown. For each component of the makeup liner material extraction, manufacturing and transport and packaging up until assembly are included in the results. For the Sprout makeup liner assembly, product packaging and transport of the product to the customer are shown separately. Please notice that the different impact categories should not be compared since the indicator units are different and thus not comparable. Positive numbers in the LCA results indicate environmental burdens and negative numbers indicate environmental benefits.

TABLE 27: LIFE CYCLE IMPACT ASSESSMENT RESULTS

IMPACT CATEGORY	INDICATOR	TOTAL	MAKEUP FORMULA	WOODEN CASING	LID	CAPSULE	WOOD FLOUR	SEEDS	GLUE	ASSEMBLY	PACKAGING	TRANSPORT TO CUSTOMER	USE PHASE	END OF LIFE PHASE	PLANT GROWTH AND DECAY
Climate change - fossil	kg CO2 eq	**2,5E-02**	5,4E-03	1,3E-03	2,2E-03	4,6E-04	2,3E-05	6,3E-06	1,1E-04	2,9E-03	1,1E-02	2,3E-03	-3,6E-04	-8,3E-04	2,2E-03
Climate change - biogenic	kg CO2 eq	**3,8E-02**	4,7E-03	2,0E-04	4,7E-04	2,0E-04	6,0E-06	5,2E-07	2,6E-06	1,8E-03	1,8E-02	1,9E-05	2,4E-03	1,4E-03	9,3E-03
Climate change - CO2 uptake	kg CO2 eq	**-5,0E-02**	-4,2E-03	-3,8E-03	-3,9E-03	-2,9E-04	-9,5E-05	-2,1E-05	-3,7E-06	1,1E-04	-2,7E-02	-1,2E-05	7,5E-03	7,8E-06	-1,9E-02
Climate change - land use and transf.	kg CO2 eq	**1,5E-03**	2,5E-03	2,6E-06	-1,1E-03	8,9E-06	1,2E-07	1,2E-07	6,0E-08	8,6E-07	6,4E-05	8,9E-07	-3,9E-06	4,0E-08	5,3E-06
Stratospheric ozone depletion	kg CFC11 eq	**7,3E-08**	2,0E-08	7,7E-10	4,3E-08	2,4E-10	1,3E-11	1,0E-10	1,1E-10	2,8E-09	4,1E-09	1,0E-09	1,2E-09	-1,3E-09	1,6E-09
Freshwater eutrophication	kg P eq	**3,1E-05**	1,3E-05	4,4E-07	4,5E-06	1,2E-07	5,1E-09	3,2E-09	2,5E-08	1,9E-06	1,1E-05	1,6E-07	-1,5E-07	-6,9E-08	1,2E-06
Marine eutrophication	kg N eq	**9,0E-06**	6,7E-06	6,0E-08	1,7E-07	2,6E-08	8,5E-10	7,2E-08	3,4E-09	1,1E-06	8,8E-07	1,6E-08	-1,6E-09	-5,2E-10	1,3E-07
Mineral resource scarcity	kg Cu eq	**3,6E-04**	3,2E-04	2,6E-06	1,4E-06	1,1E-06	4,7E-08	2,4E-08	2,6E-07	4,9E-06	3,8E-05	4,0E-06	-1,9E-06	-2,2E-06	1,8E-05
Fossil resource scarcity	kg oil eq	**6,1E-03**	1,4E-03	4,1E-04	3,2E-04	1,4E-04	8,0E-06	1,3E-06	3,7E-05	8,2E-04	3,0E-03	8,0E-04	-1,0E-04	-7,2E-04	5,7E-04
Water consumption	m3	**5,8E-04**	2,3E-04	4,0E-06	9,1E-05	6,8E-06	1,1E-07	1,1E-07	2,6E-06	4,1E-05	2,7E-04	4,3E-06	-6,2E-05	-1,0E-05	2,8E-03

8 LIFE CYCLE INTERPRETATION

8.1 CONTRIBUTION ANALYSIS

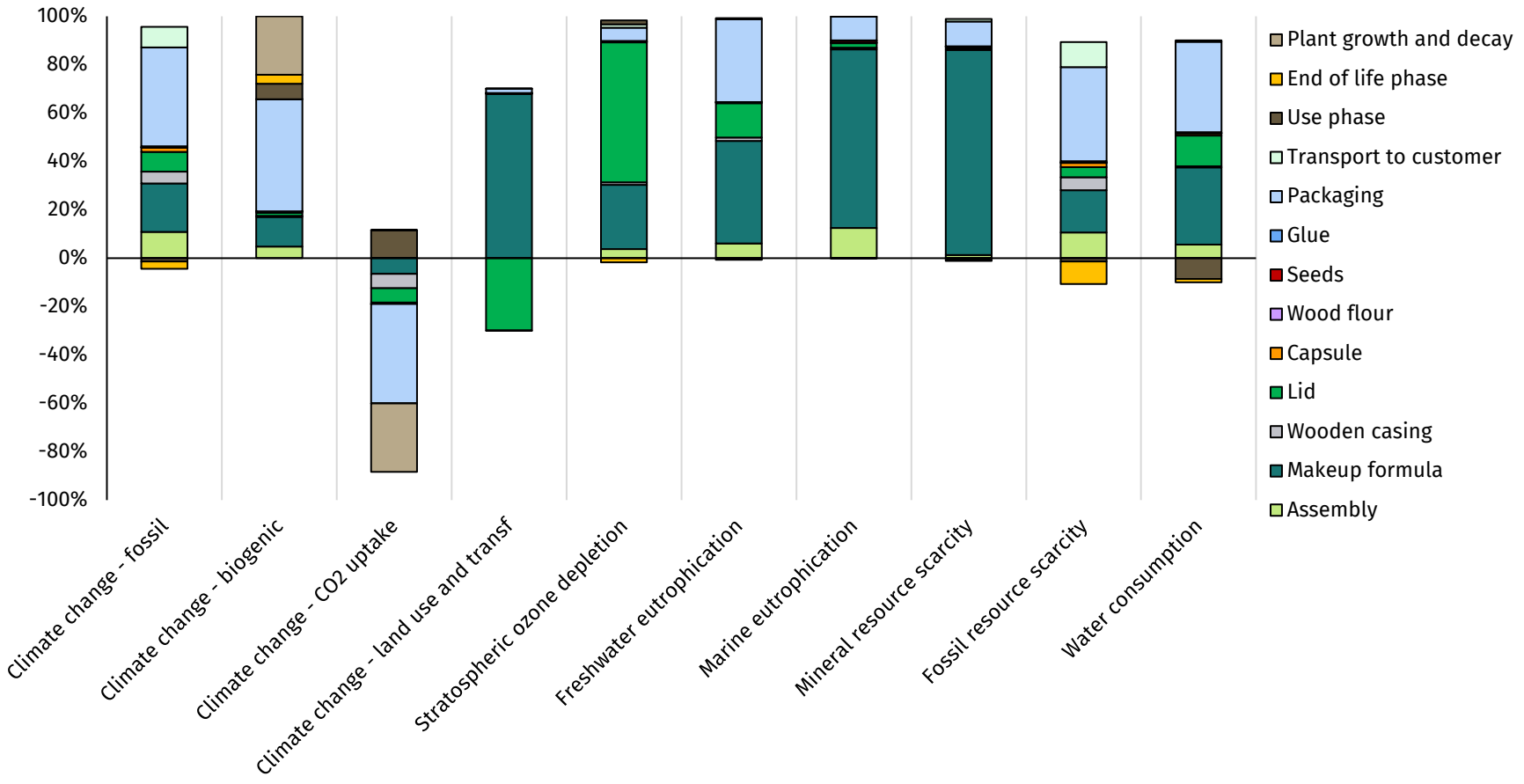

FIGURE 2: CONTRIBUTION OF PROCESSES TO EACH IMPACT CATEGORY IN THE LCA

The contribution of each process in the life cycle of the Sprout makeup liner to each impact category is shown in Figure 2. Two processes stand out in the results in most of the impact categories; the product packaging and the makeup formula. In Table 28 the top 3 most contributing processes to each impact category are shown. Positive numbers in the LCA results indicate environmental burdens and negative numbers indicate environmental benefits.

TABLE 28: TOP 3 MOST CONTRIBUTING PROCESSES TO EACH IMPACT CATEGORY IN THE LCA

IMPACT CATEGORY	INDICATOR	1. MOST CONTRUBUTING PROCESS	2. MOST CONTRUBUTING PROCESS	3. MOST CONTRUBUTING PROCESS
Climate change - fossil	kg CO2 eq	Packaging	Makeup formula	Assembly
Climate change - biogenic	kg CO2 eq	Packaging	Plant growth and decay	Makeup formula
Climate change - CO2 uptake	kg CO2 eq	Packaging	Plant growth and decay	Use phase
Climate change - land use and transf.	kg CO2 eq	Makeup formula	Lid	Packaging
Stratospheric ozone depletion	kg CFC11 eq	Lid	Makeup formula	Packaging
Freshwater eutrophication	kg P eq	Makeup formula	Packaging	Lid
Marine eutrophication	kg N eq	Makeup formula	Assembly	Packaging
Mineral resource scarcity	kg Cu eq	Makeup formula	Packaging	Assembly
Fossil resource scarcity	kg oil eq	Packaging	Makeup formula	Assembly
Water consumption	m3	Packaging	Makeup formula	Lid

The most contributing process to each impact category for the product packaging is shown in Table 29. Electricity consumption and electricity mix is shown to be a very important factor in the packaging impact and thus the Sprout makeup liner life cycle. The packaging system evaluated here is based on a Polish electricity mix. Two other packaging systems are evaluated in section 8.2.1 which are based on a Danish electricity mix.

TABLE 29: MOST CONTRUBUTING PROCESS TO EACH IMPACT CATEGORY FOR PRODUCT PACKAGING

IMPACT CATEGORY	INDICATOR	1. MOST CONTRUBUTING PROCESS
Climate change - fossil	kg CO2 eq	Electricity
Climate change - biogenic	kg CO2 eq	Direct emissions of CO2
Climate change - CO2 uptake	kg CO2 eq	Pulpwood
Climate change - land use and transf.	kg CO2 eq	Ink
Stratospheric ozone depletion	kg CFC11 eq	Electricity
Freshwater eutrophication	kg P eq	Electricity
Marine eutrophication	kg N eq	Electricity
Mineral resource scarcity	kg Cu eq	Acrylic varnish
Fossil resource scarcity	kg oil eq	Electricity
Water consumption	m3	Electricity

The most contributing process to each impact category for the makeup formula is shown in Table 30. Both the oil- and wax based ingredients, the pigments and the triglycerides contribute significantly to different impact categories. The oil- and wax based ingredients are all modeled as vegetable oil from the average global market in this LCA. This introduces a relatively high uncertainty in these results. The results should only be used as an indicator for the magnitude of the impact.

TABLE 30: MOST CONTRUBUTING PROCESS TO EACH IMPACT CATEGORY FOR MAKEUP FORMULA

IMPACT CATEGORY	INDICATOR	1. MOST CONTRUBUTING PROCESS
Climate change - fossil	kg CO2 eq	Pigments
Climate change - biogenic	kg CO2 eq	Oil- and wax based ingredients
Climate change - CO2 uptake	kg CO2 eq	Oil- and wax based ingredients
Climate change - land use and transf.	kg CO2 eq	Oil- and wax based ingredients
Stratospheric ozone depletion	kg CFC11 eq	Triglycerides
Freshwater eutrophication	kg P eq	Oil- and wax based ingredients
Marine eutrophication	kg N eq	Triglycerides
Mineral resource scarcity	kg Cu eq	Pigments
Fossil resource scarcity	kg oil eq	Pigments
Water consumption	m3	Oil- and wax based ingredients

Plant growth and decay shows some impact in the biogenic emissions and CO2 uptake categories. This indicates that the plants have the potential to even out some of the CO2 that is released by other processes in the life cycle. Nevertheless, this part of the life cycle of the Sprout makeup liner is highly uncertain since it requires the customer to plant the pencil after use, and because there was a lack of data for this part of the LCA. The results regarding growth and decay of the wildflowers should be used with care.

8.2 SENSITIVITY ANALYSIS

8.2.1 SPROUT MAKEUP LINER PACKAGING SYSTEMS

The Sprout makeup liners come in three different packaging systems described in Table 19. The box for “gift box 2 pcs” and “gift box 3 pcs” is the same with the number of makeup liners being the only difference. In this LCA the “single box 1 pcs” was used as the default scenario, and the influence on the results when using either of the two other packaging systems will be assessed here. The sensitivity analysis is shown in Figure 3. The results shown are for the whole life cycle of the Sprout makeup liner while varying the packaging system. The results are shown relative to the highest scenario in each impact category.

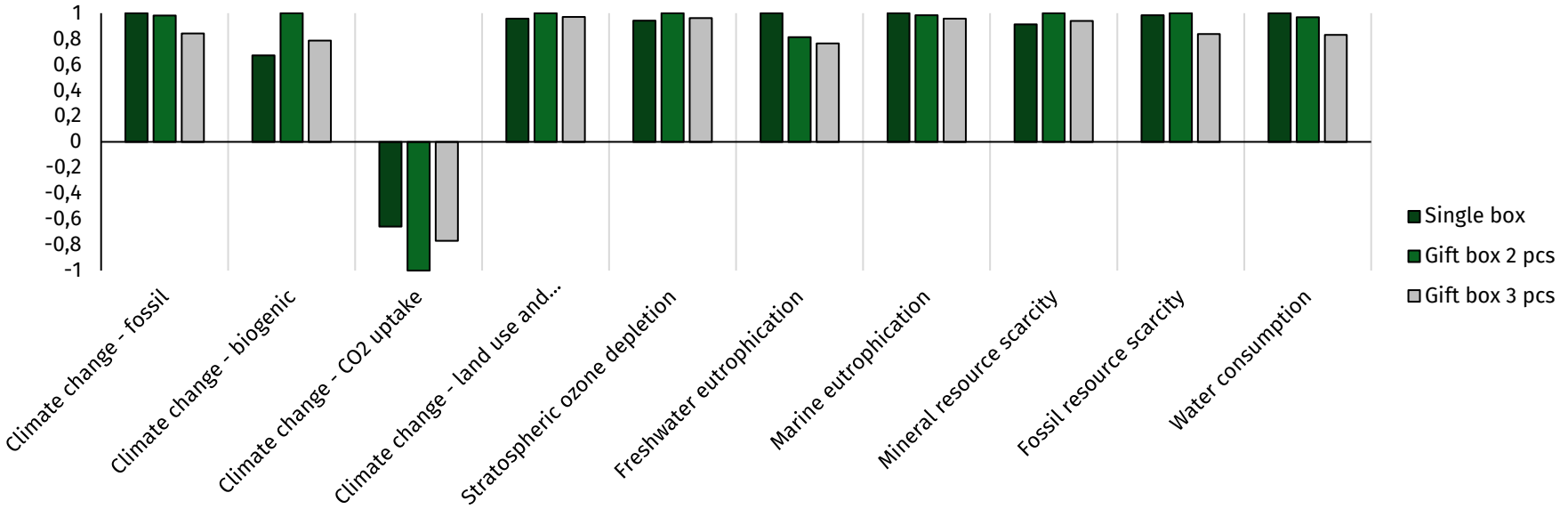

FIGURE 3: SENSITIVITY ANALYSIS FOR PACKAGING SYSTEMS (RESULTS FOR 1 SPROUT MAKEUP LINER)

It is seen that the fossil climate change impact decreases when using “gift box 2 pcs” and “gift box 3 pcs” although the box weight per pencil increases. This is due to these two packaging systems being produced in Denmark instead of Poland. The magnitude of the biogenic climate change

and CO2 uptake impacts increase when using the “gift box 2 pcs” and “gift box 3 pcs” which is due to a higher use of biomass to produce electricity in Denmark compared to Poland. The sensitivity analysis indicates that the choice of location for production of packaging has an influence on the environmental impact of the packaging. Nevertheless, reducing the amount of packaging could be equally or more important.

8.2.2 TRANSPORT TO CUSTOMER IN THE US

Transport by truck through European distribution centers and to European customers was used as the default scenario in this LCA. Sprout also sells makeup liners to other parts of the world and using other transport methods such as air freight. Therefore, transport by plane to a customer in the central US has been assessed in this sensitivity analysis. 299 km of truck in Europe was compared with 8990 km of plane and 540 km of truck in the US. The sensitivity analysis is shown in Figure 3.

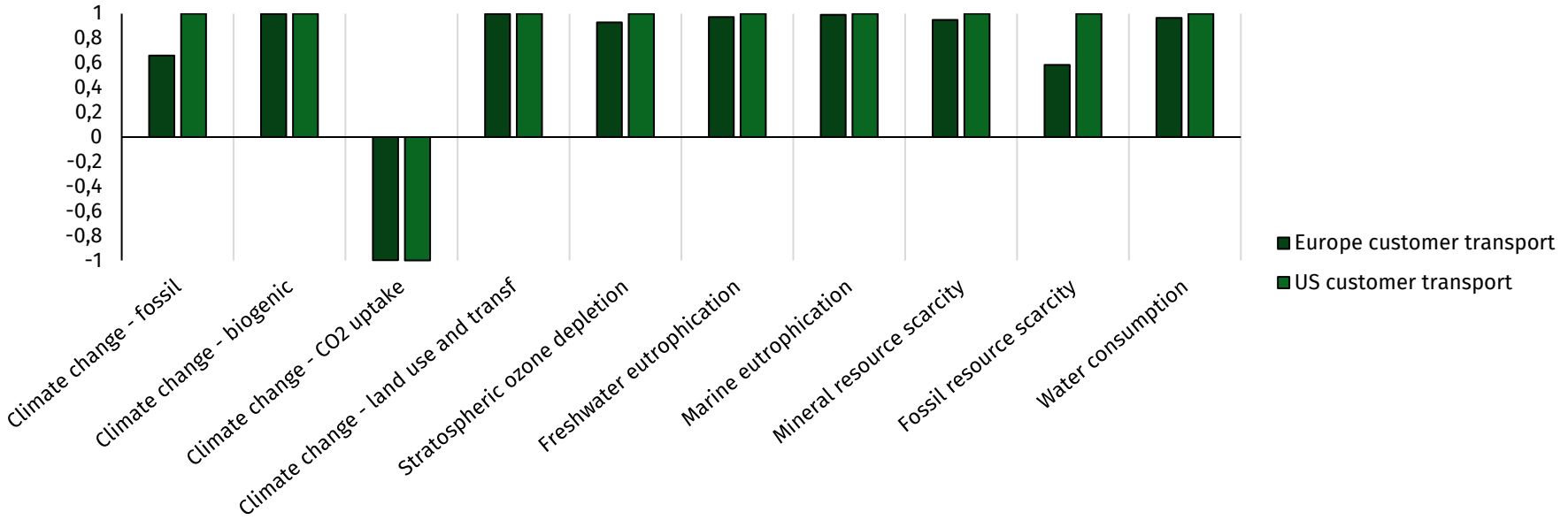

FIGURE 4: SENSITIVITY ANALYSIS FOR TRANSPORTATION TO CUSTOMER (RESULTS FOR 1 SPROUT MAKEUP LINER)

The results shown are for the whole life cycle of the Sprout makeup liner while varying the product transport scenario. The results are shown relative to the highest scenario in each impact category. It is seen that the fossil climate change and fossil resource scarcity impact categories

increase significantly when changing the transport scenario from Europe to the US. This indicates that the transport to the customer may be a relevant aspect to reduce the impact of the Sprout makeup liner regarding fossil resources and emissions. There is no significant change in the other impact categories when transporting the product by plane to a customer in the US instead of transporting solely by truck to a customer in Europe.

8.3 CONCLUSION

The Sprout makeup liner has been assessed using life cycle assessment. The most environmentally impactful processes in the life cycle were found to be the sourcing of ingredients for the makeup formula and the makeup liner product packaging. Three different systems for product packaging were assessed with production of boxes in Poland and Denmark. The electricity mix in the packaging production had some impact on the climate impact of the packaging showing a lower fossil CO2 emission from packaging produced in Denmark although the packaging systems produced in Denmark were heavier. The makeup formula ingredients were to a large extent not available in the life cycle database used for this LCA, thus “proxy datasets” were used for these materials. This resulted in a high uncertainty in the results surrounding the makeup ingredients. Since the makeup formula ingredients contributed largely to many environmental impact categories, the makeup formula ingredients could be assessed further in the future. The assembly site over which Sprout has the most control in the life cycle also showed to be impactful for fossil climate change, marine eutrophication, mineral resource scarcity and fossil resource scarcity. This indicates that Sprout has the potential to reduce overall environmental impacts by reducing fossil fuel and energy consumption, increasing the use of renewable energy and reducing waste at the assembly site. Transport of the product to a European customer was found not to have a large contribution to the environmental impact of the Sprout makeup liner. Nonetheless, the product transport had some impact when transporting to a US customer using air freight from Europe to the US.

9 REFERENCES

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