SOLE 2020 LCA: Active Thick & Performance Thick Footbeds

Final Report & Methodology

Updated July 19, 2021

The report below provides the methodology and final report comprising SOLE's preliminary LCA (Life Cycle Assessment) for its Active Thick and Performance Thick footbeds, conducted by GreenStep Solutions.

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Executive Summary

The report below outlines the findings and recommendations from SOLE's 2020 Life Cycle Analysis (LCA). The primary objective of this LCA project was to measure carbon impacts of SOLE's footbeds, across its supply chain, by building a calculator to depict these impacts at each life cycle stage. This data can be used by the SOLE team to (a) to communicate its footprint to its customers, (b) highlight areas for improvement, and (c) establish a baseline emissions footprint from which future life cycle efforts can be measured against. The products assessed included two footbeds types: Active Thick and Performance Thick.

A Life Cycle Analysis (LCA) is an evaluation of the carbon, water, and waste impacts of a product throughout its entire life cycle, including raw material extraction and processing, manufacturing, distribution, use, and recycling or final disposal. Such a study can be used to promote the responsible choices made by SOLE/ReCORK throughout the initial stages of the life cycle, such as raw material selection and sourcing; and provide insight to help further reduce impacts along all stages. This LCA focused specifically on carbon impacts per life cycle stage, with a final calculation estimating the total CO2e (carbon dioxide equivalent) per pair of footbeds.

SOLE's overall impact on a per-pair-of-footbeds basis is demonstrated in the below overview table, and further analysis is provided in the following report.

Product	**Total CO2e (kg)**
One Pair Active Thick Footbed	2.86
One Pair Performance Thick Footbed	2.34

Total carbon impacts (kg CO2e per footbed) for SOLE's primary footbed products: Active Thick and Performance Thick.

SOLE Management Forward

The following comments have been provided by SOLE management.

SOLE has commissioned Greenstep to complete an LCA analysis at the product level specific to footbeds produced by SOLE. As detailed in the following report, this analysis is a comprehensive cradle to grave analysis.

By definition, cradle-to-grave scope boundaries start with and include the extraction of the raw materials used in the production of any goods. In the case of the cork forests, measuring only the extraction of the cork bark fails to truly capture the on-going ecosystem services provided by the continued existence and maintenance of the forest in order for cork bark to be harvested in the first place.

While GHG accounting protocols and standards are still developing in this area, SOLE cannot claim to have the benefit of a “carbon credit” from the ecosystem services of the forest itself. However, we have taken a similar approach to cork industry raw material producers by highlighting and quantifying the ecosystem services provided by the ongoing demand for and thus existence of the cork forests. We have linked to several studies that have calculated the CO2 sequestration values per hectare of the cork oak forests as modelled over time.

The point here is to educate and help people understand there is an ecological value to the cork forest's continued existence and we can quantify that value in CO2 sequestered by the cork forest, from where the cork bark is harvested.

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Introduction

SOLE is a sustainable insole and supportive footwear brand, manufacturing a variety of footbeds for myriad uses. GreenStep conducted a carbon impact LCA for SOLE's 2020 production of two of its primary products: Active Thick and Performance Thick Footbeds. The primary difference between the two is the base layer of material: Active Thick includes ethylene-vinyl acetate while the Performance Thick includes natural cork.

This report outlines the findings and recommendations based on the data outputs from the LCA calculator.

The key objectives of this LCA were to:

1. Calculate the total life cycle carbon footprint of SOLE's primary footbeds
2. Produce a report that provides the carbon impact of each product, along with the methodology for the calculations
3. Provide a spreadsheet calculator for the SOLE team to assist in their own calculations

Goal & Scope

GreenStep has conducted a life cycle analysis (LCA) of the carbon impact from two of SOLE's primary product offerings: the Active Thick footbed and the Performance Thick footbed.

GreenStep quantified the carbon impact of SOLE's primary products based on its 2020 production - from cradle to grave - with the results and methodology detailed within this final report. Starting with the extraction and processing of the materials listed in the table below, GreenStep calculated the carbon footprint per pair of SOLE footbeds, through their manufacture, distribution, and point of purchase, to their end of useful life.

A note on cork: SOLE sources raw cork granules from a supplier based in Portugal, where the majority of cork found in the world is grown and harvested. Additionally, SOLE also collects used corks across North America as part of its ReCORK program; these corks are ground and reprocessed into SOLE's products. For this LCA exercise, SOLE provided

GreenStep with cork carbon emission data generated from Ernst & Young, on behalf of SOLE's cork supplier.

The following products were assessed for the SOLE LCA calculator:

Products

- Active Thick Footbed
- Performance Thick Footbed

Formulations

SOLE uses similar materials in each of its footbeds, with the primary difference being the base layer. In the Active Thick Footbed, this layer is composed of ethylene-vinyl acetate, while in the Performance Footbed, this layer is composed of natural cork. Below is a general breakdown of footbed formulation:

	Active Thick footbed	Performance Thick footbed
1. Cork base		✔
2. Ethylene-Vinyl Acetate (EVA) base layer	✔	
3. Polyurethane (PU) Rubber cushioning layer	✔	✔
4. 35% recycled Polyethylene top sheet fabric	✔	✔

Environmental Inputs & Outputs

A full LCA typically identifies potential impacts from global warming, acidification, eutrophication, ozone depletion, photochemical ozone, and primary energy; however, for the purposes of this study, the focus was on the carbon impact from the creation, use, and disposal of SOLE's two primary footbeds. To that end, the following environmental inputs and outputs were assessed:

- Inputs: raw materials, energy, waste
- Outputs: kg CO_2e (carbon dioxide equivalent)

System Boundary

In order to establish a scope boundary for this methodology, the team at GreenStep met with SOLE to identify the products to be assessed, along with all raw material extraction and processing inputs, footbed manufacturing details, transportation mechanisms, consumer use-phase information, and end-of-life estimates. In combination with primary data obtained from SOLE and its supply chain partners, GreenStep also conducted secondary research to gather industry standards, relevant coefficients, and background primers on the various processes outlined below.

Following data collection, GreenStep built a LCA calculator that would showcase differences in impact across both primary footbed products, from “cradle” to “grave.” The primary output of the calculator is a series of values that rank the impact of each SOLE product in the area of carbon dioxide emissions. The “cradle” for each footbed begins with the collection of raw materials, moving on to processing into material suitable for footbed manufacturing and continues on from there, with the “grave” being the end-of-life stage of each product (in this case, 100% to landfill).

Below, under the Transportation process, we have listed “warehouse/retail gate” - this is different from the footbed “grave.” The “gate” is defined as the last step that the footbed takes along its transportation journey to reach a SOLE customer. Following that, the footbed is then used by the customer and eventually reaches its “grave” (i.e., the landfill). The system boundary was defined as follows:

Processes included:

- Raw material processing
    - Cork oak harvest and pre-processing
    - Polyethylene recycling
    - Extraction and processing of polyurethane (PU) rubber aka “Softec”
    - Extraction and processing of Ethylene-Vinyl Acetate aka “EVA”
    - Processing of cork binders, hotmelt, and glues
- Footbed manufacturing
    - Energy consumption from SOLE manufacturing plants
- Transportation from cradle (raw materials) to warehouse/retail “gate”
- Consumer Use and End-of-Life Scenarios (“grave”)

Processes not included

- Ink production
- Carbon impact from stickers
- Cork recycling
- Cork oak tree CO_2 sequestration

Functional Units

- 1 pair each of SOLE's Active and Performance Thick footbeds

Methodology

This LCA consists of the following phases: raw materials and formulation; footbed manufacturing; packaging; transportation (upstream and downstream); warehousing/retail; consumer care; and waste. GreenStep aligned its methods and data management protocols against the Greenhouse Gas Protocol guidance. Specific methodologies for each phase are listed below, and are associated with a similarly-named tab in the "SOLE LCA Calculator - Full Output & LCA Steps." It should be noted that in the spreadsheet, GreenStep has colour coded certain data in the following ways:

Colour Legend
Assumptions*
GreenStep Values
Values calculated, not used

**While all of the data in the calculator is modifiable, these values are specific values that the GreenStep team assumed during data processing, and can/should be updated as SOLE obtains more specific primary data.*

Flow Charts

The below flow charts illustrate the process flow of materials for SOLE's primary footbeds, from raw ingredients to landfill.

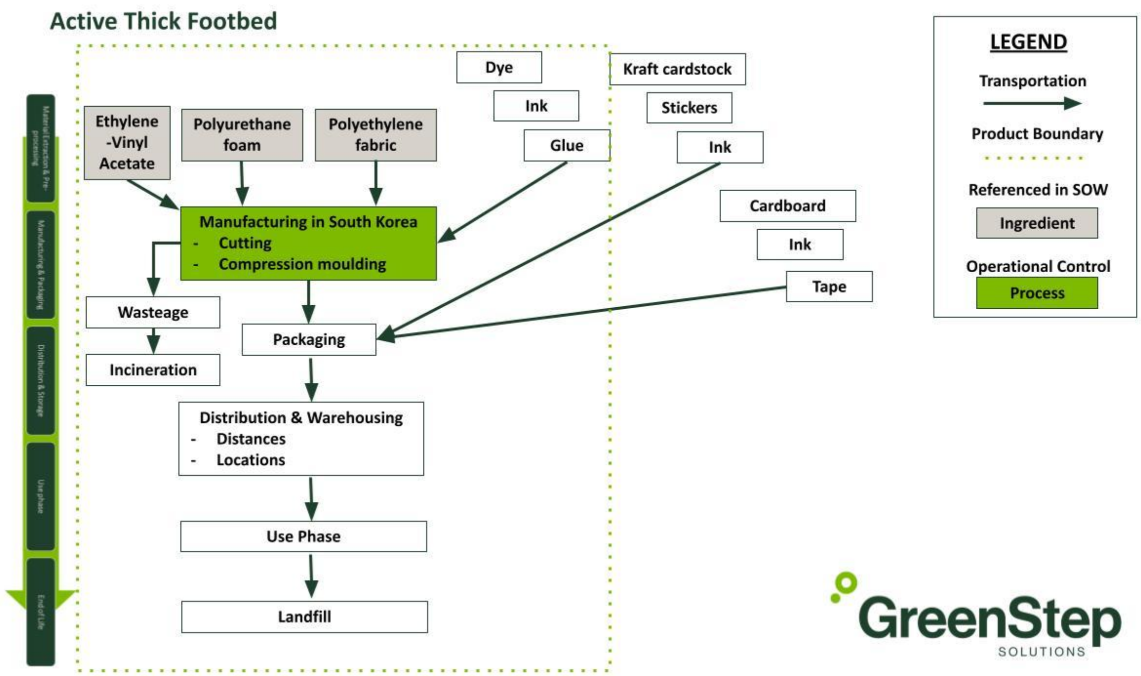

Figure 1: Active Thick Footbed flow chart

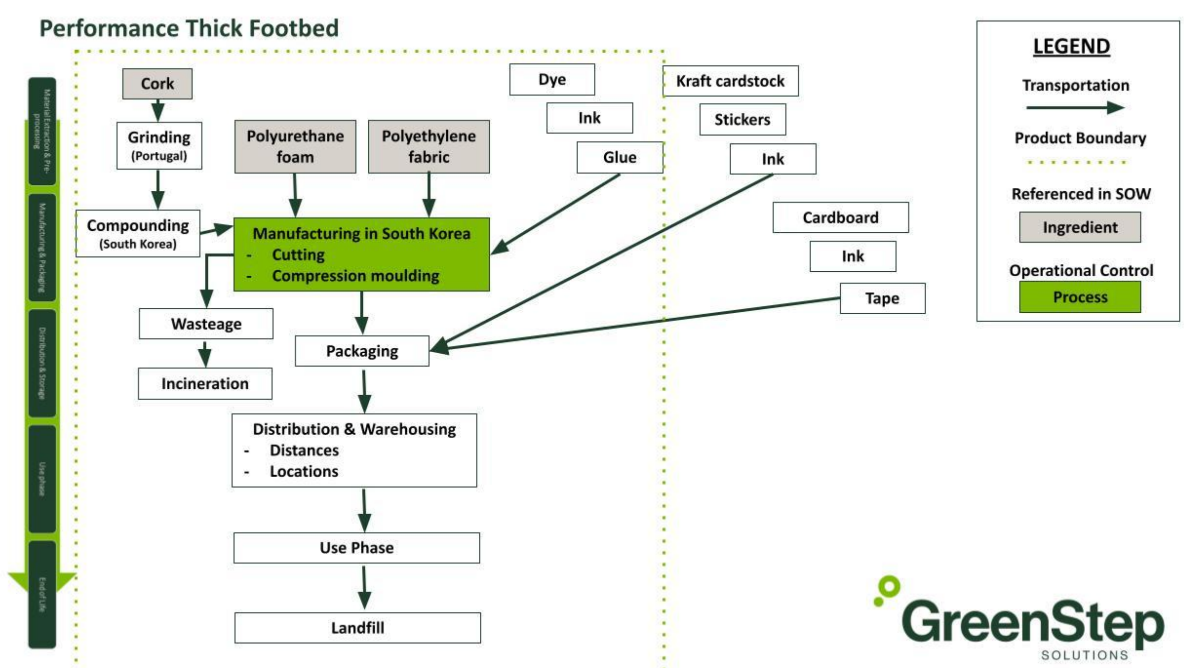

Figure 2: Performance Thick Footbed flow chart

Raw Materials & Formulation

Using SOLE's purchasing records, GreenStep first divided the total amount of raw materials ordered in 2020 by the total 2020 yield to calculate the total amount of material required to manufacture a pair of footbeds (inclusive of waste). From there, GreenStep used those weights to approximate the total weight of material required to manufacture a footbed, and the percentage of the total contributed by each material.

GreenStep sourced third-party life cycle data from the HIGG Materials Sustainability Index for raw material inputs including, EVA, Softec, recycled polyethylene topsheet; as well as for bonds. These values were then multiplied by the weight of the particular material in question (i.e., the weight per pair of footbeds of "Cork Base" was multiplied by the cork CO2e factor).

Cork values were sourced from the Ernst & Young Sparkling Cork Stopper carbon footprint report (2019) provided to GreenStep by SOLE. The values incorporated into the LCA included: stored carbon, forest management, treatment and disc production, granulate production, and stopper production.

The total CO2e per pair of footbeds at the Raw Materials & Formulation stage is simply a summation of all CO2e values per ingredient, per pair of footbeds (for Active Thick, this is a sum of cells G9-K9; for Performance Thick, this is a sum of cells E12-L12).

Manufacturing

Total electricity consumption from SOLE's South Korean manufacturing facility was provided to GreenStep and divided by the total 2020 yield to determine the amount of energy required per pair of footbeds manufactured. This is likely over estimated slightly, as the total kWh would include consumption not directly related to manufacturing (e.g. facility lighting).

The total CO2e per pair of footbeds at the Manufacturing stage (D5 and D6) is calculated by multiplying the kWh per pair of footbeds by an emission factor for Asian energy consumption (measured in kg CO2e/kWh).

Packaging

Packaging values were calculated based on the weight of packaging per pair of footbeds, along with a specific emission factor for each packaging material (i.e. recycled cardstock and recycled cardboard boxes). Due to their minimal quantity and weight, stickers were omitted from packaging calculations.

The total CO2e per pair of footbeds at the Packaging stage (D7) is a sum of all CO2e for all packaging (cells D3-D6) on a per pair of footbed basis.

Upstream Transportation

Transportation was defined by the approximate distance travelled (kilometers) between all processing, manufacturing, and warehousing locations; the mode of transport (either road/truck or ocean freight); and divided into upstream and downstream emissions. SOLE provided us with kilometer distances between raw material receiving, manufacturing, and landfill (for manufacturing waste). GreenStep approximated the remaining distances using Google Earth and Google Maps.

Upstream transportation emissions include the transportation of raw materials and packaging materials to SOLE's manufacturing facility in South Korea; as well as manufacturing waste to landfill.

The total CO2e per pair of footbeds for Upstream Transportation (D10 and D12) is a sum of all upstream CO2e emissions, calculated by multiplying kilometers per route (row 5) by the emissions factor per mode of transportation (row 7) by the weight of raw materials (row 9 or row 11).

Downstream Transportation

Downstream transportation emissions include the shipping of footbeds from South Korea to warehouses in Washington State, California, British Columbia, Alberta, as well as Sweden. Additionally, GreenStep assumed an average distance from warehouse or retail to the end customer.

The total CO2e per pair of footbeds for Downstream Transportation (AA10 and AA12) is a sum of all downstream CO2e emissions, calculated similarly as Upstream, by multiplying

multiplying kilometers per route (row 5) by the emissions factor per mode of transportation (row 7) by the weight of raw materials (row 9 or row 11). These values were then multiplied by the percentage transported to each warehouse location, respectively. SOLE provided GreenStep with a percentage breakdown; those percentages are indicated in the calculator under the “Transportation” tab.

Warehousing/Retail

GreenStep first estimated the total amount of footbeds warehoused or retailed, based on the total yield of footbeds provided by SOLE and an assumed 50% warehouse/50% retail split. The total number of boxes of footbeds was calculated by dividing these values by 24 (the number of products packed into a master carton box). GreenStep then calculated how much energy was consumed per master carton of footbeds, based on how much area each box occupied in a typical warehousing or retail setting.

Total CO2e per pair of footbeds at the Warehousing/Retail stage (I9) is a sum of total CO2e for retail and warehouse, calculated by multiplying the total CO2e (G7 or G8) by % of yield (H7 or H8).

Consumer Care

Customers have two “care” options when breaking in their SOLE footbeds: either wear-mould or bake them in a 200°F oven for two minutes. GreenStep assumed that 50% of SOLE customers would wear-mould the footbeds while the other 50% would bake them.

Total CO2e per pair of footbeds at the Consumer Care stage was calculated by multiplying the kilograms of CO2e for each of the care options (mould or bake) by 50%. To calculate CO2e per care option, total kilowatt hours were multiplied by an energy grid emission factor for the state of Utah (see assumptions).

Waste

GreenStep calculated waste values at both manufacturing and end-of-life stages. At the manufacturing stage, GreenStep has assumed that 80% of SOLE’s Cork Binder, Bonds and Hotmelt materials evaporate during manufacturing, as reported by SOLE’s manufacturing partner. As such, GreenStep has not included these weights in “Sum of Ingredients” (Raw Materials & Formulation) for waste (M7 and M10). Instead, M7 and M10 account for wastage of EVA, Softec and topsheet only. These waste figures were calculated using the total wastage reported by SOLE's manufacturing partner (25,920kg) divided by the total materials purchased in 2020 (71,411) which equals 50.22%.

End-of-life waste was calculated based on an assumed scenario that 100% of SOLE footbeds are landfilled at the end of their usable life. This section also accounts for packaging waste, an assumed 60% of which is landfilled with the remaining 40% recycled.

Total CO2e per pair of footbeds at the Waste stage (F4 and F5) is a sum of all CO2e per end-of-life scenario (B4-E4; or B5-E5). To calculate CO2e per scenario, GreenStep multiplied the weight (in kilograms) of waste per pair of footbeds by its respective emission factor (B10-B14).

Assumptions

Raw Materials & Pre-Processing

- Total weights are based on a pair of footbeds (vs. individual)
- GreenStep has assumed a conservative CO2 emission factor to account for cork oak harvest and processing, using values from a 2019 Sparkling Cork Stopper Carbon Footprint report by Ernst & Young.
- Assume the same CO2 emissions factor for bonds, hotmelt, and cork binder (L22)

Manufacturing

- Assume zero cork wastage, as the cork product is pressed into a mould (rather than cut out of a sheet)
- Assumed zero ink wastage
- Assumed an average Asian energy coefficient from the International Energy Agency

Transportation

- Cork granules travelling from Portugal to Hongcheon-gun assumed to travel via ocean freight through the Suez Canal - kilometers calculated using Google Earth
- Truck/road used as mode of transport to customers; assume an average distance between warehouse or retail location and customer to be 1,000 kilometers
- 8% of footbeds are warehoused in Sweden (as the European mid-point for distribution)

Warehousing/Retail

- 50% of total footbeds produced went to warehousing, 50% to retail
- Two months residency time in retail; four months for warehousing
- Assumed standard dimensions for a master carton ship box (1.7'x1.3'x1.2')

Consumer Care

- 50% of footbeds are wear-moulded, 50% are oven-baked
- GreenStep used an energy grid factor from the State of Utah (USA) to account for the electricity consumption of an electric oven (0.809kg CO_2e/kWh). This factor is higher than the factor used for warehousing and retail, where an emission factor of 0.165kg CO_2e/kWh was used (based on Western America Grid data). This difference lies mainly in the fact that Utah generates its electricity from coal-fired power plants, whereas “western America” encompasses a variety of power sources. Because of this, the Consumer Care value is likely an overestimation for any customer not on a coal-powered energy grid, but is also a more comprehensive (and conservative) value in a global context, as many countries around the world still use coal power and have not yet switched to renewable energy sources.

Waste

- 100% of footbeds are landfilled at the end of their useable life
- 60% of packaging waste is landfilled; 40% is recycled

LCA Output Tables

The below data include the final outputs from SOLE’s Life Cycle Analysis calculator (Table 1), and impacts per life cycle stage (Table 2). These data identify impacts from SOLE’s primary footbed products: its Active Thick and Performance Thick footbeds, from raw material production to end-of-life, identified as carbon emissions (kg CO_2e) per pair of footbeds.

Product	Total CO_2e (kg)
One Pair Active Thick Footbed	2.86
One Pair Performance Thick Footbed	2.34

Table 1: SOLE LCA Calculator Final Output per footbed type

Product	Raw Material Extraction & Pre-processing kg CO2e	Upstream Transportation kg CO2e	Manufacturing kg CO2e	Packaging kg CO2e	Downstream Transportation kg CO2e	Warehouse & Retail kg CO2e	Consumer Care kg CO2e	Solid Waste kg CO2e	Total kg CO2e per footbed
Active Thick Footbed	0.7776	0.0011	0.6874	0.5943	0.2497	0.0347	0.0467	0.4649	2.8564
Performance Thick Footbed	0.3129	0.0374	0.6874	0.5943	0.2291	0.0347	0.0467	0.3978	2.3402

Table 2: Total CO2e impacts per life cycle stage for SOLE's Active Thick and Performance Thick Footbed

Interpreting Results

Overall Impact: From the above results, it can be shown that the Performance Thick Footbed has a lower carbon footprint than the Active Thick Footbed. This difference is likely due to a variety of factors including the quantity produced (less Performance Thick footbeds were manufactured in 2020) as well as the lower footprint of natural cork as a raw material, as compared to ethylene-vinyl acetate (a fossil-fuel-based material).

Carbon emissions per LCA stage: Carbon impacts for SOLE footbeds overall are greatest at the raw material extraction and pre-processing stage, as well as at the manufacturing and packaging stages.

As noted above, based on the calculations in this LCA, the Active Thick Footbed has a higher impact at the raw materials stage, likely due in part to its inclusion of ethylene-vinyl acetate (EVA) as the primary base material. Ethylene-vinyl acetate is derived from fossil fuels, whereas cork is a natural product; this difference can be observed in the CO2e factors for these raw materials (5.07kg CO2e/kg raw material and 0.589kg CO2e/kg, respectively).

Carbon impacts at the manufacturing stage can be accounted for based on the power supply of the energy grid, composed of a mix of coal, natural gas, and some nuclear power: this generates a higher emissions factor for electricity consumption (in this calculator, a value of 0.7464kg CO2e/kWh was used). In contrast, power supplied through renewable energy sources such as hydro generates a much smaller emissions factor. In British Columbia, for example, a similar emissions factor lies in the realm of 0.0093kg CO2e/kWh.

While it was not within the scope of this project to calculate the positive, climatic impact that SOLE Performance Thick footbeds have by their inclusion of natural cork (vs fully synthetic materials as with its Active Thick footbed), it must be noted that cork is a natural product that has many intrinsic environmental benefits - including its ability to sequester carbon as a living tree. SOLE's cork supplier is very clear about these claims, and has conducted multiple independent LCA studies to demonstrate these positive impacts.

Recommendations

- An LCA is only as robust as the data that goes into it. To that end,
  - GreenStep recommends that SOLE continue to collect and make use of its own primary data for inclusion in future LCA projects.
- SOLE is already investigating bio-based EVA to replace its current fossil-fuel-derived base-layer in the Active Thick Footbed.
  - GreenStep recommends that they maintain this course of action and investigate additional material types that contain a lower footprint than conventional/fossil-fuel-based materials.
- South Korea energy is produced using a combination of coal, natural gas, and some nuclear; while it is difficult to avoid these impacts from a manufacturing perspective, there are steps SOLE can take to mitigate further impact.
  - Support its manufacturing partners in transitioning to clean, less CO2 emitting energy
  - Consider switching manufacturing partners based on primary energy source
  - Purchase carbon offsets for manufacturing processes
- There are strict protocols and requirements in order to generate a carbon credit that can be passed along or sold to another entity (re: cork oak tree sequestration), to ensure that there is no double counting and other important factors.
  - GreenStep suggests that SOLE investigate the possibility of creating a verified carbon offset with their cork supplier, that can be credibly passed on to their customers.
- "Sustainability" in terms of carbon sequestration; bio-based plastics; and the complexities of carbon accounting will only become more important discussion topics as more and more companies make claims and attempt to quantify their products' impacts.

- ❏ Continue to communicate these messages to the SOLE customer base - including uncertainty or unknowns - to build transparency, trust, and authenticity.

❏ GreenStep has assumed that 100% of SOLE footbeds are landfilled at the end of their usable life. As of this writing, recycling a product like a footbed is difficult, owing to its complex material makeup and lack of recycling streams for such products.

- ❏ GreenStep recommends that SOLE continue to research the feasibility of footbed recycling and/or re-processing used footbeds into other materials, to mitigate its solid waste impacts.

❏ Work with a third-party verifier to gather robust, primary data on cork oak sequestration projects, including from any ongoing or future SOLE (or ReCORK)-funded tree-planting efforts.

Conclusions

This LCA quantifies the impact of SOLE's Active Thick and Performance Thick footbeds, demonstrating that overall, the Performance Thick Footbed has a lower carbon footprint than does the Active Thick Footbed. Not only that, but LCAs such as this act as a "road map," providing SOLE with a better understanding of *where* in the life cycle of their footbeds are the highest impact areas.

There is no such thing as a product with "zero" impact, but certain decisions made along the supply chain can make a drastic difference in the size of that impact. Knowing where the greatest impacts along a garment's life cycle occur is crucial to identifying strategies for lowering those impacts.

There is much that this LCA does not encompass, including the untold, intrinsic positive impacts that come from SOLE's customers using their footbeds (such as the myriad positive mental health benefits that come from exercise) or the aforementioned climatic benefit derived from cork oak trees. While future efforts could (and should) attempt at quantifying these intrinsic values, these present data provide a good place for SOLE to start. With the establishment of these data as its baseline, it can only improve on its impacts, further reducing its carbon footprint across its product lines.

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Appendices

The following tables are the result of the LCA calculations across all life cycle stages, separated out by stage.

Product	Raw Material Extraction & Pre-processing kg CO2e
Active Thick Footbed	0.7776
Performance Thick Footbed	0.3129

CO2e impacts at the Raw Material Extraction & Pre-processing stage

Product	Upstream Transportation kg CO2e	Downstream Transportation kg CO2e
Active Thick Footbed	0.0011	0.2497
Performance Thick Footbed	0.0374	0.2291

CO2e impacts at the Transportation stage, separated by upstream and downstream emissions

Product	Manufacturing kg CO2e
Active Thick Footbed	0.6874
Performance Thick Footbed	0.6874

CO2e impacts at the Manufacturing stage

Product	Packaging kg CO2e
Active Thick Footbed	0.5943
Performance Thick Footbed	0.5943

CO_2e impacts at the Packaging stage

Product	Warehouse & Retail kg CO2e
Active Thick Footbed	0.0347
Performance Thick Footbed	0.0347

CO_2e impacts at the Warehouse & Retail stage

Product	Consumer Care kg CO2e
Active Thick Footbed	0.0467
Performance Thick Footbed	0.0467

CO_2e impacts at the Consumer Care stage

Product	Solid Waste kg CO2e
Active Thick Footbed	0.4649
Performance Thick Footbed	0.3978

CO_2e impacts at the Solid Waste/End-of-Life stage