Revision 1

Comparative Study of BLUMAKA Foam for Footwear Midsoles Compared to Traditional Materials and Methods Using Life Cycle Assessment Methodology

Prepared for BLUMAKA

by Todd Copeland, Copeland Consultancy LLC

Revision Release Date: June 9, 2023; Initial Study Release Date: October 27, 2020

Introduction

This revision refers to the "Comparative Study of BLUMAKA Foam for Footwear Midsoles Compared to Traditional Materials and Methods Using Life Cycle Assessment Methodology" released on October 27, 2020. This revision updates and analyzes the impacts for the case where the **Blumaka processing is done in a facility powered by 100% renewable electricity.** The revision also includes updates to the data for materials and processes taken from external sources, in cases where the source data has been updated. Calculations and results were then updated accordingly.

Summary

This analysis shows that GHG emissions (carbon footprint) of Blumaka midsoles are 14-38% less than a traditional EVA version and 60-72% less than a traditional PU version.

The reductions are partially due to displacement of volume with recycled material. It is also partially due to the Blumaka process which has dramatically lower GHG emissions compared with the PU or EVA foam midsole process. **The Blumaka process achieves a factor-4 reduction in GHG emissions, meaning 4 times less impact than the traditional processes. And in the case of using renewable electricity to power the Blumaka process, process emissions are reduced to zero.**

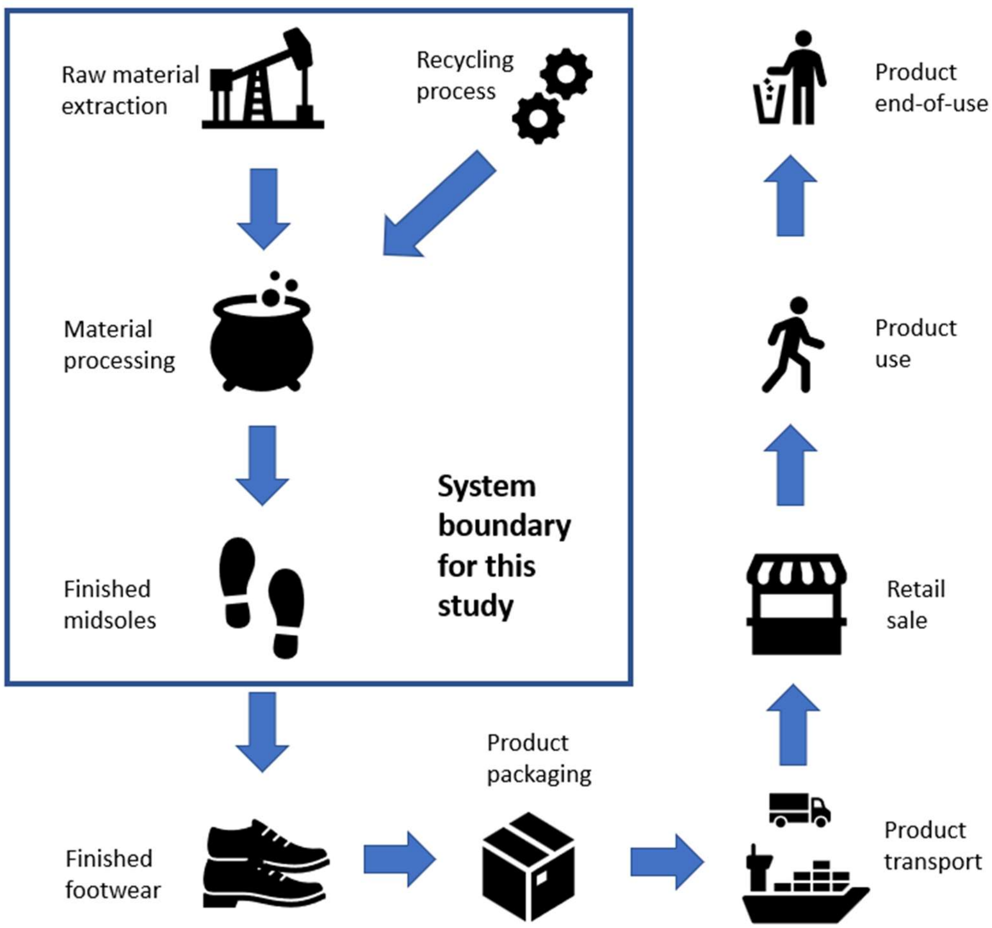
Background

In the initial study, a **Life Cycle Assessment (LCA)** methodology was used to compare the environmental impact of **Blumaka** foam with traditional foam materials. The life cycle boundaries were from extraction of origin materials to finished midsoles, and it was a comparative study using **one pair of midsoles** as the functional unit. The material inputs for traditional midsoles were **ethylene-vinyl acetate (EVA)** and **polyurethane (PU)**, using traditional processes for molding. The material inputs for Blumaka midsoles were **thermoplastic polyurethane (TPU)**, PU, and recycled foam (e.g. EVA), using Blumaka processes for molding. LCA data for EVA, PU, TPU, and traditional processes for molding were gathered from available databases. The study focused only on global warming potential from GHG emissions (so-called carbon footprint) although it was noted that other impacts of footwear production are also significant and should be taken into account in future studies.

System Boundaries and Functional Unit

The life cycle boundaries are **from extraction of origin materials to finished midsoles**. This study excludes life cycle stages such as shoe manufacturing, transportation/distribution, retail sale, use, and end-of-use disposal. The environmental impacts in these stages for Blumaka foam are assumed to be equal compared with traditional foam. There is potential for Blumaka foam to allow for lower impacts in shoe manufacturing and at end-of-use, but these scenarios are outside the scope of this study.

Diagram 1. Life Cycle Stages Included In This Study



This is a comparative study, using **one pair of midsoles** as the functional unit. This study takes a conservative approach by assuming that Blumaka midsoles are a one-to-one comparison with traditional midsoles, although lab tests indicate that the useful life for Blumaka midsoles is expected to be longer. Comparison based on a functional unit of service (days or miles of useful wear) would require more assumptions so was not chosen for this study, although the result may be more favorable to Blumaka midsoles based on longer wear durability.

Inventory

For the purpose of this study, Blumaka foam midsoles are made with recycled EVA, PU and TPU. The recycled EVA comes from manufacturing waste collected from shoe manufacturing facilities and transported to the Blumaka factory nearby for grinding. TPU sheets are added to encapsulate the combination of PU foam and ground-up recycled EVA. Traditional midsoles are made with EVA that is compression-molded or with PU that is poured into the mold. The GHG emissions for each polymer material (EVA, PU, TPU) from origin to polymer can be found in available databases. The emissions from processing steps for traditional midsoles are estimated based on closest processes found in available databases. Emissions from processing steps for Blumaka midsoles are measured and extrapolated based on the production of Blumaka products.

EVA midsoles: Raw material + Processing (Pelletizing + Mixing + Foaming + Compression molding)

PU midsoles: Raw material + Processing (Pelletizing + Mixing + Foaming + Pouring)

Blumaka midsoles: Recycled EVA (Raw material) **+ PU** (Raw material) **+ TPU Sheet:** Raw material (including Extrusion) **+ Processing** (Blumaka process)

For comparing the Blumaka midsoles to traditional midsoles, the weights of midsoles for shoes with comparative size and performance were obtained. Shoe X is the best matching comparison with the most available information and data, although it has a larger-than-average volume of foam in the midsoles. Shoe Z represents a more typical midsole volume for athletic shoe construction, and weights for EVA and PU midsoles were extrapolated based on the same traditional materials and densities as Shoe X.

Table 1. Weights for one pair of midsoles, in different versions of Shoe X

Shoe X versions	**EVA weight (kg)**	**PU weight (kg)**	**TPU weight (kg)**	**Total weight (kg)**
Blumaka midsoles	0.108 (recycled)	0.160	0.036	0.304
EVA midsoles	0.200	0	0	0.200
PU midsoles	0	0.420	0	0.420

Table 2. Weights for one pair of midsoles, in different versions of Shoe Z

Shoe Z versions	**EVA weight (kg)**	**PU weight (kg)**	**TPU weight (kg)**	**Total weight (kg)**
Blumaka midsoles	0.090 (recycled)	0.070	0.036	0.196
EVA midsoles	0.160	0	0	0.160
PU midsoles	0	0.340	0	0.340

Calculations

[Weight] x [Material Emissions per kg material] + [Process Emissions per pair] = Total Emissions

Shoe X - Blumaka Midsoles Materials and Process	Weight (kg)	Material Emissions (kg-CO2e) per kg material	Process Emissions (kg-CO2e) per pair of midsoles	Total Emissions (kg-CO2e) per pair of midsoles
Recycled EVA Component	0.108	0		0
PU Component	0.160	4.00		0.64
TPU Component	0.036	6.00		0.216
Process Emissions			0	0
Total Emissions				**0.856**

[Weight] x ([Material Emissions per kg material] + [Process Emissions per kg material]) = Total Emissions

Shoe X - Traditional Midsoles Materials and Processes	Weight (kg)	Material Emissions (kg-CO2e) per kg material	Process Emissions (kg-CO2e) per kg material	Total Emissions (kg-CO2e) per pair of midsoles
EVA Midsole	0.200	2.70	2.30	**1.00**
PU Midsole	0.420	4.00	1.14	**2.16**

[Weight] x [Material Emissions per kg material] + [Process Emissions per pair] = Total Emissions

Shoe Z - Blumaka Midsoles Materials and Process	Weight (kg)	Material Emissions (kg-CO2e) per kg material	Process Emissions (kg-CO2e) per pair of midsoles	Total Emissions (kg-CO2e) per pair of midsoles
Recycled EVA Component	0.090	0		0
PU Component	0.070	4.00		0.280
TPU Component	0.036	6.00		0.216
Process Emissions			0	0
Total Emissions				**0.496**

[Weight] x ([Material Emissions per kg material] + [Process Emissions per kg material]) = Total Emissions

Shoe Z - Traditional Midsoles Materials and Processes	Weight (kg)	Material Emissions (kg-CO2e) per kg material	Process Emissions (kg-CO2e) per kg material	Total Emissions (kg-CO2e) per pair of midsoles
EVA Midsole	0.160	2.70	2.30	**0.800**
PU Midsole	0.340	4.00	1.15	**1.75**

Results

Table 3. Shoe X: Global warming potential of different midsole materials (kg-CO2e per pair of midsoles)

Midsole	Materials	Process	Total
Blumaka	0.856	0	0.856
EVA	0.54	0.46	1.00
PU	1.68	0.479	2.16

Chart 1. Shoe X: Global warming potential of different midsole materials (kg-CO2e per pair of midsoles)

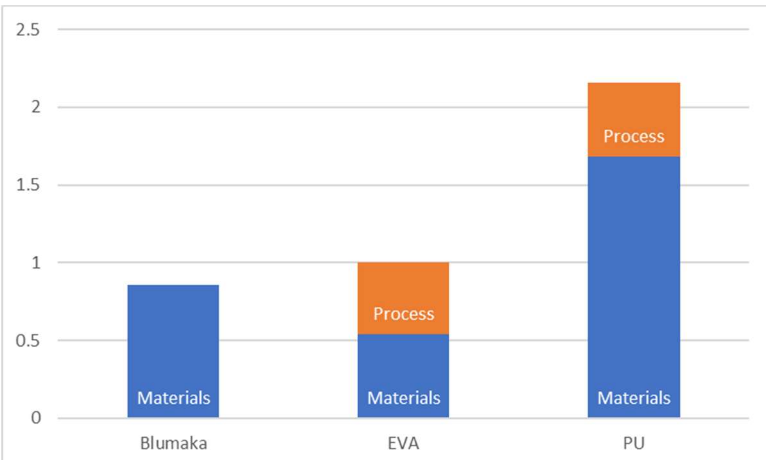


Table 4. Shoe Z: Global warming potential of different midsole materials (kg-CO2e per pair of midsoles)

Midsole	Materials	Process	Total
Blumaka	0.496	0	0.496
EVA	0.432	0.368	0.800
PU	1.36	0.388	1.75

Chart 2. Shoe Z: Global warming potential of different midsole materials (kg-CO2e per pair of midsoles)

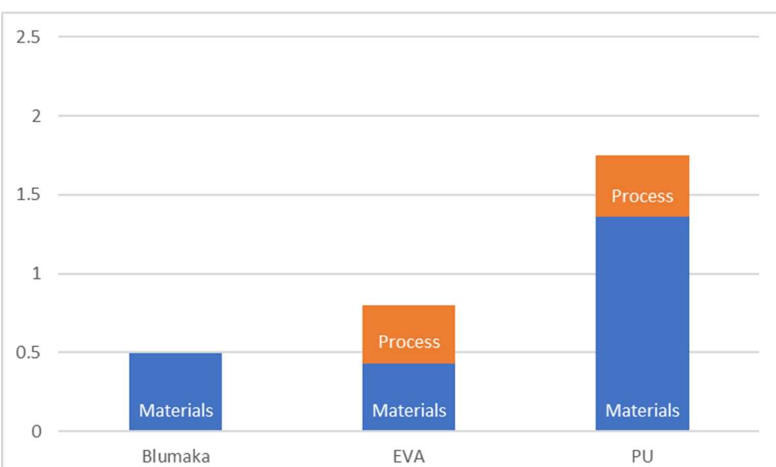


Table 5. Total emissions per pair of midsoles for the two example shoes

Midsole type	Shoe X – Total emissions (kg-CO2e) per pair of midsoles	Shoe Z – Total emissions (kg-CO2e) per pair of midsoles
Blumaka midsoles	0.856	0.496
EVA midsoles	1.00	0.800
PU midsoles	2.16	1.75

Two examples were used to compare impacts of different midsoles on shoes of similar size and performance. Shoe X was the best matching comparison with the most available information and data. The GHG emissions for one pair of Blumaka midsoles in Shoe X were determined to be 0.856 kilograms of carbon-dioxide-equivalents (kg-CO2e), compared with 1.00 kg-CO2e for the EVA version and 2.16 kg-CO2e for the PU version of the same shoe.

Shoe Z represents a more typical midsole volume for an athletic shoe construction, and weights for EVA and PU midsoles were extrapolated based on the same traditional materials and densities as Shoe X. For Shoe Z, the GHG emissions for one pair of the Blumaka midsoles were determined to be 0.496 kg-CO2e, compared with 0.800 kg-CO2e for the EVA version and 1.75 kg-CO2e for the PU version.

Analysis

According to available databases, GHG emissions embedded in the base material by kilogram is much higher for PU (4.00 kg-CO2e) compared with EVA (2.70 kg-CO2e). Conversely the process emissions for making EVA foam midsoles by compression molding are higher (2.30 kg-CO2e) than making PU foam midsoles by pouring (1.14 kg-CO2e). However, PU foam is typically denser than EVA foam as used in footwear midsoles, so the total emissions of PU midsoles are higher than the emissions of the EVA version in both Shoe X and Shoe Z.

The Blumaka midsoles are a combination of PU and recycled material (e.g. EVA), encapsulated in TPU. This study has allocated zero impact to the recycled EVA material, based on the value of the waste material. Transportation of waste EVA was calculated as insignificant, and processing waste EVA is included in the Blumaka process. The TPU sheet, although used in small amount, has the highest level of embedded GHG emissions (6.00kg-CO2e) of all the materials in this study.

Shoe X has a larger-than-average volume of foam in the midsoles. The Blumaka version (with renewable energy powering the factory) achieves a **14% reduction** in emissions compared with a traditional EVA version and a **60% reduction** in emissions compared with a traditional PU version.

Shoe Z represents a more typical midsole volume for an athletic shoe construction, and weights for EVA and PU midsoles were extrapolated based on the same traditional materials and densities as Shoe X. For Shoe Z, the Blumaka midsoles (with renewable energy powering the factory) achieve a **38% reduction** compared with traditional EVA midsoles and a **72% reduction** compared with traditional PU midsoles.

The reductions achieved by Blumaka are partially due to displacement of total PU volume with recycled material, in this case recycled EVA. It is also partially due to the Blumaka process which has dramatically lower emissions (0.108 kg-CO2e per pair of midsoles) compared with the PU or EVA foam midsole process (0.368 to 0.479 kg-CO2e per pair of midsoles). Even before accounting for use of renewable energy, the Blumaka process achieves **a factor-4 reduction** in GHG emissions, meaning **4 times less impact than the traditional processes. And in the case of using renewable electricity to power the Blumaka process, process emissions are reduced to zero.**

Table 6. Process emissions per pair of midsoles for the two example shoes

Midsole type	Shoe X – Process emissions (kg-CO2e) per pair of midsoles	Shoe Z – Process emissions (kg-CO2e) per pair of midsoles
Blumaka midsoles (100% RE)	0	0
Blumaka midsoles	0.108	0.108
EVA midsoles	0.460	0.368
PU midsoles	0.479	0.388

Discussion of Limitations and Opportunities for Further Improvement

The impact of scrap waste is significant to the findings of this study. It should be noted that the amount of waste from producing one pair of Blumaka midsoles is included in the total material inputs. Waste materials from traditional processes are also included and are based on the most conservative estimates from industry experts. The recommendation to Blumaka could be to reduce the amount of scrap waste, which they have reported will improve as production volume increases. It was noted that scrap waste (PU foam and TPU sheet) from the Blumaka process will be repurposed into other products. But for the purposes of this study, the total amount of material including scrap waste was used to calculate the impact of making midsoles by the Blumaka process (and by traditional processes). It is also possible that the traditional scrap waste estimates for EVA (10%) and PU (5%) midsole production are underreported, which would make the traditional materials and methods look more favorable in this study.

The impact of using TPU in the Blumaka midsoles is significant to the findings of this study. Although used in small amounts, the impact per kilogram of this material is high. The recommendation to Blumaka could be to optimize the thickness (and therefore the weight) of the TPU for each application, which they have reported is under investigation to use the minimum amount required to meet each end product's performance specifications. Another recommendation could be to use recycled TPU, and Blumaka have reported that a TPU with 50% recycled content (from their own scrap waste) is in development.

Although this study focuses on midsole components, the TPU shell design allows the Blumaka midsoles to be used as midsole/outsole components. There may be an environmental impact reduction achievable at a product level by using a thicker TPU and eliminating the need for a rubber outsole, while meeting the same durability specifications. And durability tests have shown that a Blumaka midsole/outsole component with a TPU shell could achieve higher durability than a so-called surface-contact EVA midsole/outsole component, which could increase the product's service life in the use phase and therefore reduce the product's environmental impacts from a full life cycle perspective.

The impact metrics in LCA methodology are often, as in this study, based on weight of materials so that in the case of foam occupying the same volume, a lower density foam would have lower impacts than a higher density foam of the same material. In general, this approach makes sense that more material equals more impact. But it does not accurately represent a process that requires the same input of energy and other resources for a given volume or number of units regardless of weight or density. In such a case, a lower impact is allocated in the LCA methodology to a lower density material but in practice, the resource consumption and environmental impact is the same for a given volume or number or units. In this way, process impact metrics per kilogram of material tend to assign a superficially lower impact to low-density materials, and a superficially higher impact to high-density materials. This density bias skews the results in this study and others in favor of low-density materials.

This study focuses only on global warming potential from GHG emissions (so-called carbon footprint) although other impacts of footwear production are also significant and should be taken into account in future studies. For example, water is used in traditional compression molding to cool the molds. Also, chemicals are used in traditional midsole processes such as silicone-based mold release and solvents to remove the silicone. The Blumaka process does not require cooling water or mold release chemicals, and a study that included these impacts could quantify the reduction in water use and human and environmental impacts from chemicals. In addition, the Blumaka process may enable further reductions if downstream manufacturing steps are included.

References

Interviews and documentation from Blumaka, courtesy of Stuart Jenkins

Ecoinvent Database v3

The Higg Materials Sustainability Index (Higg MSI)

US EPA Center for Corporate Climate Leadership website: www.epa.gov/climateleadership