

# **Life cycle assessment of a pair of GORE-TEX® branded waterproof and breathable hiking boots.**

## Summary report

Study according to DIN EN ISO 14040

W.L Gore & Associates' Fabrics division is committed to using sound science and continuously improving the environmental impact of its products. To support this commitment the division carried out a cradle-to-grave LCA (Life Cycle Assessment) of a pair of GORE-TEX® branded hiking boots which are representative of a major business area of Gore's Fabrics division: consumer footwear.

A Life Cycle Assessment is a standardised technique used to evaluate all the environmental impacts linked to the different steps of the product life cycle, from raw material extraction, processing and production right through to the use phase and disposal.

This report is an update and complement to the previous LCA work on functional outerwear carried out by Gore Fabrics since 1992. Its aim is to assess GORE-TEX® branded apparel's environmental performance, and identify opportunities to optimize these products' environmental footprint.

The Institute for Applied Ecology of the Öko-Institut Freiburg e.V. provided Gore with critical guidance on the methodology and data-sets.

The report passed a third party critical review, which was provided by Rita Schenk, Ph.D. LCACP, head of the Institute for Environmental Research. The Institute for Environmental Research is an independent not for profit organisation based in Vashon Island, Washington, USA.

# 1 GOAL

## 1.1 Main goal

The LCA's main goals are:

- Assess the environmental performance of GORE-TEX® branded footwear
- Provide a benchmark of the life cycle emissions of a pair of GORE-TEX® branded hiking boots throughout their complete life cycle
- Help designers understand the impact of the products they are designing, and identify future opportunities to improve the environmental impact of Gore fabrics products

## 1.2 Update study

This study updates and complements the previous LCA work on functional outerwear of the Gore Fabrics division by:

- Improving the data quality, through the use of up to date dyeing and finishing data provided by bluesign® technologies in an aggregated form
- Including more details on the use phase
- Adding footwear to Gore's portfolio of LCA analyses, as well as functional outerwear

# 2 PRODUCT SYSTEM

Gore chose to model a typical pair of waterproof and breathable hiking boots that would represent a high volume of products purchased and used in continental Europe. To be consistent with the geographic location of sales, Gore decided to model a typical European usage and end of life scenario.

Boot features:

- Nubuck suede upper
- Vibram® EVO injected sole
- GORE-TEX® footwear lining
- Weight: 1110g/pair in size 8
- Available sizes: 6.5 – 12, 13, 14

The boots are assumed to last three and a half years, based on expected usage.



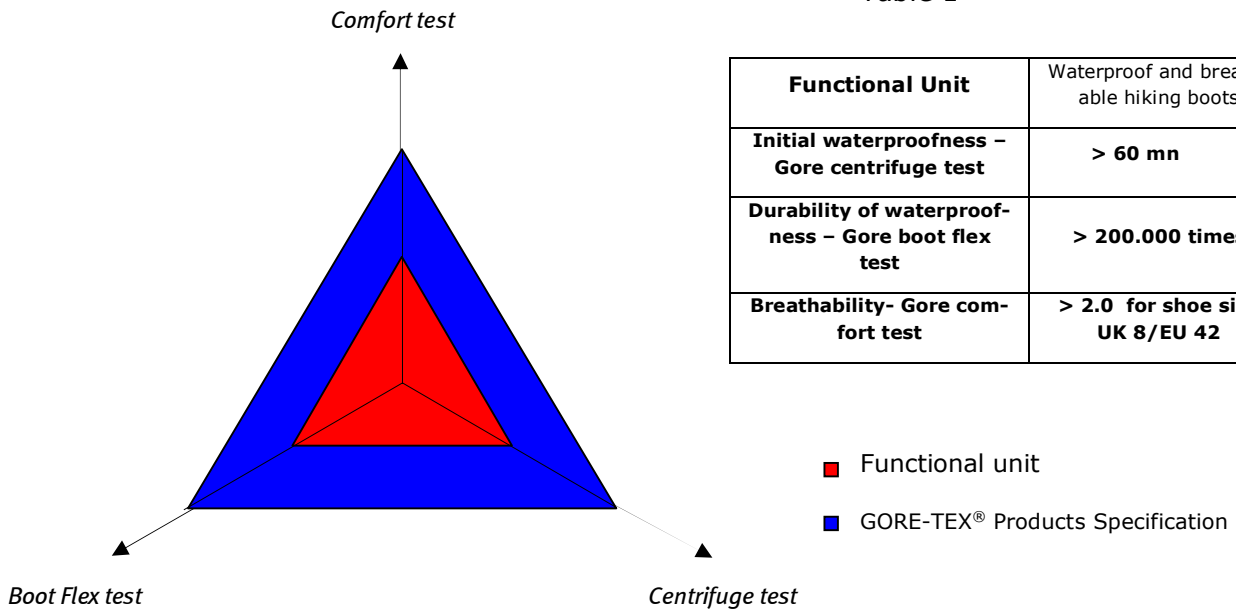
### 3 FUNCTIONAL UNIT

A functional unit is a measure of the service delivered by the product. It provides a reference to which the inputs and outputs are related to. The interest of the functional unit approach is to have a reference unit that enables the comparison between two products that provide an equivalent service. For this study, the functional unit was defined as: "The use of a single pair of durably waterproof and breathable hiking boots for category B1 outdoor activities, lasting 3.5 years."

The boots are assumed to be treated with a shoe cream and re-impregnated with a water repellency treatment twice a year, and last three and a half years, while continually fulfilling the minimum performance criteria described in Table 1.

Table 1

Functional Unit	Waterproof and breathable hiking boots
Initial waterproofness – Gore centrifuge test	> 60 mn
Durability of waterproofness – Gore boot flex test	> 200.000 times
Breathability- Gore comfort test	> 2.0 for shoe size UK 8/EU 42



For this, the life cycle inventory data set collected during previous studies was updated. This included both the update of averaged industry data as well as substituting industry data with primary factory data, whenever possible. The study assessed a single pair of waterproof and breathable hiking boots.

- <sup>1</sup> Category B: hikes in the low level mountains and trekking trips in the major mountain ranges of the world on marked mountain paths

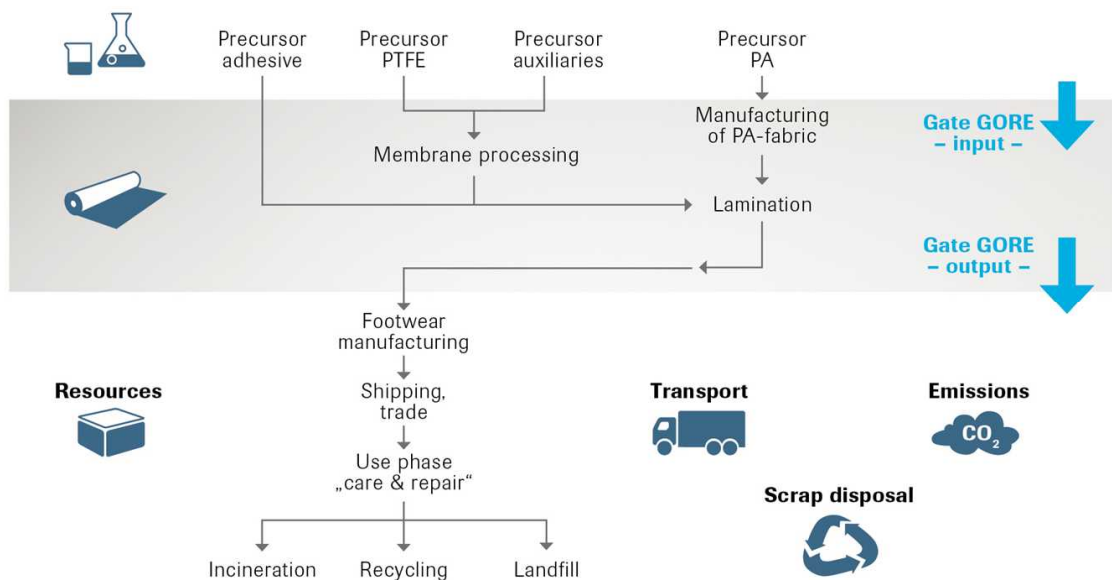
## 4 SCOPE AND ASSUMPTIONS

The study was conducted in full compliance with the DIN EN ISO 14040:2006 and DIN EN ISO 14044:2006 standards. This means that the evaluation was not limited to the functional fabric produced by Gore. Instead the scope included the assessment of the finished product over the whole life cycle, from “cradle to grave”.

This includes the upstream processes, such as the manufacture of adhesive, PTFE, auxiliaries and polyamide. These materials enter the Gore manufacturing plants, where the ePTFE-membrane processing takes place. In the next step, textile and membrane are connected with an adhesive during what is called the lamination process. Finally, the laminate and seam tape are shipped to the manufacturer for assembly into finished footwear. Notably, no DWR (Durable Water Repellent) treatment is applied to footwear laminates.

After the boots have been manufactured in Slovakia, they are packed and distributed via a central distribution hub to European consumers. Transport is assumed to take place by overland truck. The consumer trip to the retailer was estimated as a single 10 km return trip in an average car.

After a three and half year use phase the boots are assumed to end up either in a landfill or in an incinerator in Europe. Over this period of time, the boots are assumed to be cared for twice a year with a gentle warm water wash, leather treatment and restorative application (water repellent treatment by the consumer).



Gore being a material supplier with limited direct access to upstream and downstream manufacturing processes, acquiring primary data for this “cradle to grave” LCA presented a challenge. Generally, Gore’s own processes and its fluoropolymer precursor chains were calculated using primary data. However, despite the support of suppliers and customers, some downstream processes had to be modelled based on commercially available databases, such as the Ecoinvent database. Bluesign technologies ag also provided an aggregated dataset on textile manufacturing relevant to the Gore

supply chains. Unless otherwise stated, Gore’s own processes and its fluoropolymer precursor chains were calculated using primary data.

Data on the actual product lifetime and the consumer care of footwear is not readily available. After ample discussions with brands and footwear experts, Gore decided to use a three and a half year lifetime for the study. The assumed lifetime for this study is believed to be a relatively conservative assumption for GORE-TEX® branded hiking boots, based on accumulated experiences with outdoor consumers over the years.

It must be noted though; that a real life scenario with a shorter or longer useful lifetime, depending on the frequency of use, usage conditions and whether or not the boots are resoled could change the outlook of the results.

## 5 RESULTS

Over the entire lifetime of a pair of GORE-TEX® branded waterproof and breathable hiking boots - from cradle to grave - a total Global Warming Potential of 27.1 kg of CO<sub>2</sub>-eq., a Freshwater Eutrophication of 0.00734 Kg of Phosphate-eq. are emitted and 476.5 MJ of primary energy is used.

Detailed ReCiPe Midpoint (H) results:

ReCiPe Midpoint Results	Acronym	Unit	Result
Climate change	GWP100	kg CO <sub>2</sub> eq.	2,71E+01
Ozone depletion	ODPinf	kg CFC-11 eq.	8,17E-06
Terrestrial ecotoxicity	TETPinf	kg 1,4-DCB	2.80E-03
Terrestrial acidification	TAP100	kg SO <sub>2</sub> eq.	1,92E-02
Freshwater ecotoxicity	FETPinf	kg 1,4-DCB	1,62E-01
Freshwater eutrophication	FEP	kg P eq.	7,34E-03
Marine eutrophication	MEP	kg N eq.	3,05E-02
Marine ecotoxicity	METPinf	kg 1,4-DCB	1,47E-01
Human toxicity	HTPinf	kg 1,4-DB eq.	6,33E+00
Photochemical oxidant formation	POFP	kg NMVOC	7,00E-02
Particular matter formation	PMFP	kg PM10 eq.	3,24E-02
Ionising radiation	IRP_HE	kg U235 eq.	5,58E+00
Metal depletion	MDP	kg Fe eq.	6,57E-01
Water depletion	WDP	m <sup>3</sup>	2,41E-01
Fossil depletion	FDP	kg oil eq.	9,28E+00
Agricultural land occupation	ALOP	m <sup>2</sup> a	8,25E-01
Urban land occupation	ULOP	m <sup>2</sup> a	1,99E-01
Natural land transformation	NLTP	m <sup>2</sup>	7,50E-03

Assessing the contributions that single stages of the life cycle have on the overall impact values shows consistent results for most impact categories: **materials and distribution are responsible for the vast majority of these impacts while the disposal of the boots has a negligible impact.** Beyond the obvious need to focus on materials and distribution to reduce the boots impact, the product’s lifetime was identified as the single most influential factor to influence the overall environmental impact of a pair of hiking boots.

## 6 CONCLUSIONS

The main findings of this study can be summarised as follows:

- **The production of the boots materials and the distribution** have an important impact: 77% of Global Warming Potential (GWP)
- The impact of **longevity** on the annual ecological impact is such that the boots' life time is the **single most influential parameter for improving most environmental impacts**
- Manufacturing the boot has a consistently smaller impact, regardless of the considered impact indicator
- The **End Of Life stage has a negligible impact** compared to other life cycle stages. In this case it represents 1,7% of the boots' GWP

### 6.1 Materials

**The production of the boots materials** (Polymer fabrics, finished leather, Gore processes incl. PTFE, metal, etc.) **has the most important impact** on the considered indicators: 50.6% of GWP.

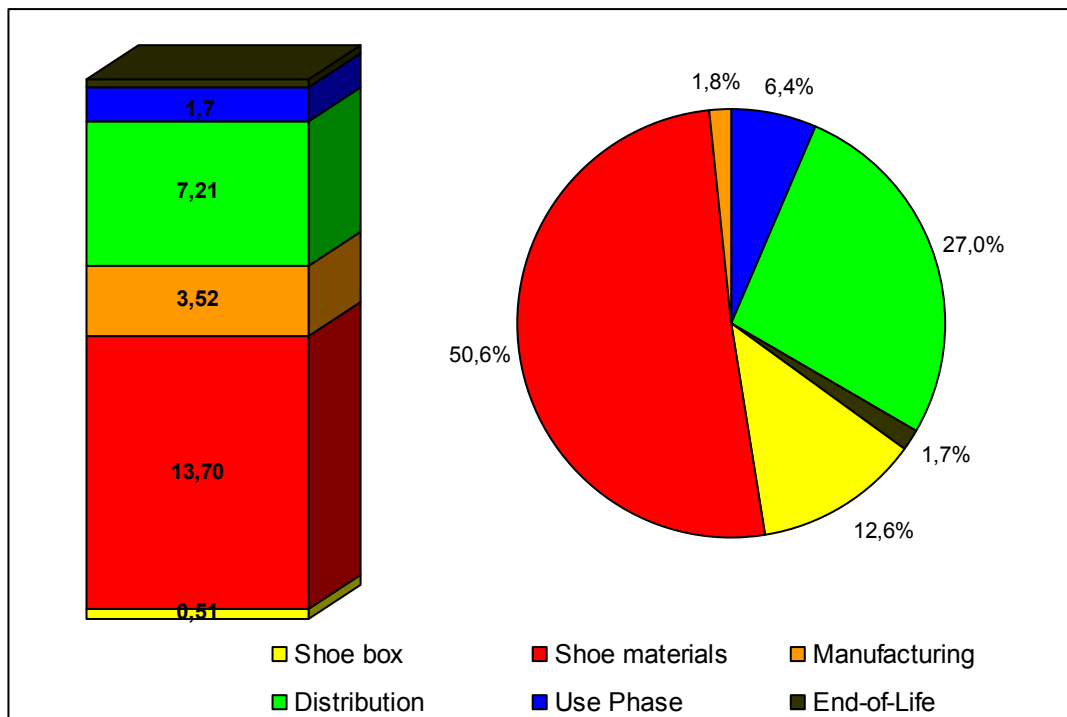


Figure 2: GWP of a pair of GORE-TEX® branded hiking boots in Kg of CO<sub>2</sub> eq.

The global warming (GWP) and Freshwater Eutrophication (FEP) indicators highlight that the impacts are mainly incurred during the production of the polymers used in the sole as well as the upper components which include Leather and the GORE-TEX® lami-

nate & seam tape. Together these materials represent 50.6% of GWP and 53.2% of FEP of all of the raw materials used in the boot.

Focusing on these materials will provide the best opportunities to reduce the boots' impact. However, much of this lies outside of Gore's direct control. Therefore engaging with upstream suppliers and brand customers is a prerequisite to improve GORE-TEX® branded hiking boots environmental performance.

## 6.2 Distribution

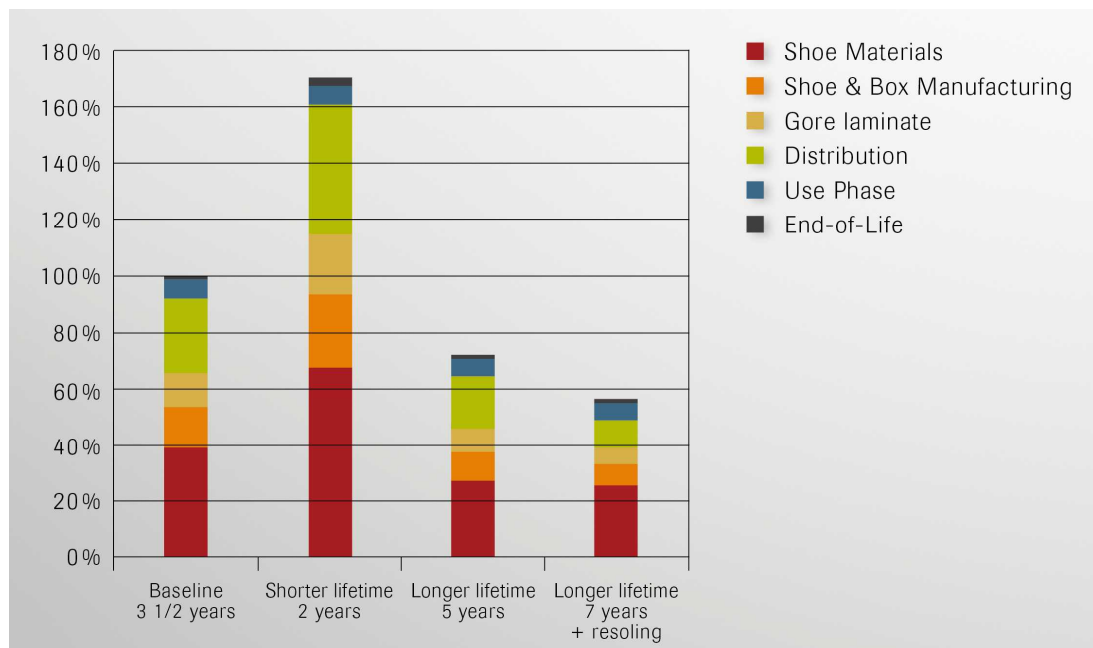
**The distribution stage of this study**, that takes into account transport from the production site to the warehouse, transport from the warehouse to the store, in store electricity usage (heating/cooling & lighting) and customer transport for the purchase (20km round trip) **represents 27% of GWP** and 25% of FEP. Our analysis shows that 98% of this linked to in-store electricity consumption and the customer's shopping trip. Focusing on these stages will provide the best opportunities to reduce the impact of transport and distribution.

## 6.3 Longevity

Running a sensitivity analysis on the effects of longevity on the LCA results, enabled Gore to identify that the impact of **longevity** on the annual ecological impact **was the single most influential parameter for improving several environmental impacts**. In total 9 scenarios, including the baseline scenario, were developed to test our results.

Scenario	1 Base line	2 short life-time	3 long life-time	4 re-soling
Life time	3.5 y	2 y	5 y	7 y

What these scenarios show is that the boot's **longevity is the single most influential parameter for improving several environmental impacts**.



In other words, the longer a pair of boots lasts, the smaller its annual environmental impact will be

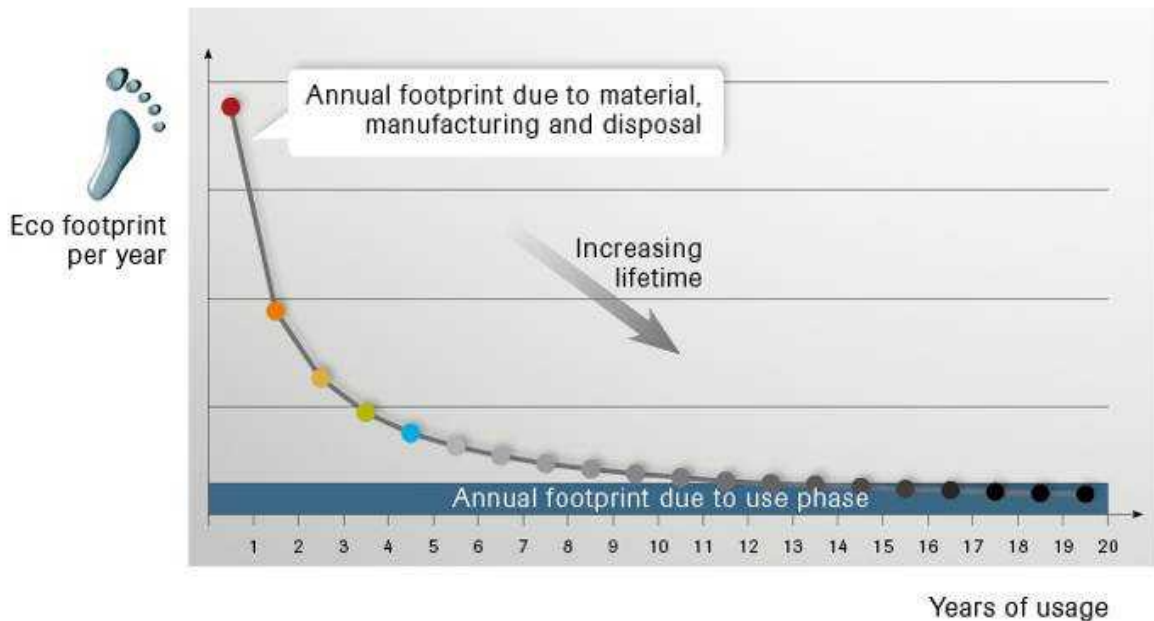


Figure 3: Annual GWP of a pair of GORE-TEX® branded hiking boots in Kg of CO<sub>2</sub> eq.

## 6.4 Annual GWP

Having already used the French Grenelle framework for the choice of the impact indicators to focus on, Gore decided to use the functional unit within the French framework to derive an annual footprint. Applying this means that Gore could also communicate a yearly carbon footprint that would be equal to boots' GWP divided by the assumed lifetime.

$$\text{Annual GWP} = \text{GWP} / \text{lifetime}$$

$$\text{Annual GWP} = 27.1/3.5$$

$$\text{Annual GWP} = 7.7 \text{ Kg CO}_2 \text{ eq. / year}$$



## 7 RECOMMENDATIONS

Based on the results of this study, Gore derived a set of recommendations that should help reduce the environmental impact of producing, selling and using GORE-TEX® waterproof and breathable hiking boots. Here are a few of those recommendations:

### 7.1 Materials

- A careful and informed choice of materials has the potential to reduce the boots impact. Considerations should include:
  - Potential for using less impactful materials and dyeing methods for the fabrics
  - Utilization of hides from grass fed cows, and leather from Leather Working Group (LWG) gold rated tanneries
  - Impact of material durability on longevity and useful lifetime of the footwear in its intended use
- For energy intensive raw materials which cannot be easily changed due to performance and/or durability considerations, the switch from fossil to renewable energy should also be considered

As a component supplier to the footwear manufacturer, Gore's ability to influence raw material choices for the footwear design is limited. But Gore does have the opportunity to work cooperatively with the upstream and downstream textile supply chain and also through its choice of fabrics for its GORE-TEX® laminates.

### 7.2 Distribution

- Keep manufacturing as close as possible to retail operations
- Build retail stores to green standards and applying "Best Available Technologies" in terms of energy consumption reduction and conservation will ensure lower energy consumptions in stores
- Combine the purchase of a pair of boots with other trips
- Use of energy efficient vehicles, public transport and car pooling for making the shopping trip

### 7.3 DURABILITY

- Choose long-lasting materials, even at the cost of higher "ecological impacts" during material provision and manufacturing – e. g. for an abrasion resistant shoe upper. They will easily be compensated by a longer life time of the final product
- Design boots to enable sole repair/replacement and make these services easily accessible to extend the useful life of boots