Life Cycle Assessment of a GORE branded waterproof, windproof and breathable jacket.

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 functional GORE-TEX® jacket which is representative of a major business area of Gore's Fabrics division: consumer functional outerwear.

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:
- Assessing the environmental performance of GORE-TEX® branded apparel & footwear
- Providing a detailed statement on the environmental impact of one GORE-TEX® outdoor garment throughout its complete life cycle.
- Identifying future opportunities to improve the environmental impact of Gore fabric 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, using up to date dying and finishing data provided by bluesign® technologies in an aggregated form
- Including more details on the use phase
- Including footwear as well as functional outerwear

This will also be the first results of a LCA of functional apparel to be shared with the industry.

2 PRODUCT SYSTEM

We chose to model a waterproof and breathable jacket that would represent a large volume of products. This led to the choice of a jacket sold in North-America. To be consistent with the geographic location of sales, we decided to model a typical North American usage and end of life scenario.

Features:
- seam sealed
- Zip-in compatible
- Fully adjustable, removable drop hood with lower face protection
- Collar lining
- Centre-front zip and Velcro® closure,
- Pit-zips
- Biceps pocket; internal chest zip pocket
- Average weight: 900g
- Length from centre back: 30 in.
- Fabric: 94 g/m² and 134 g/m² nylon
- GORE-TEX® Performance Shell two layer fabric

The jacket is assumed to last five years.

3 FUNCTIONAL UNIT

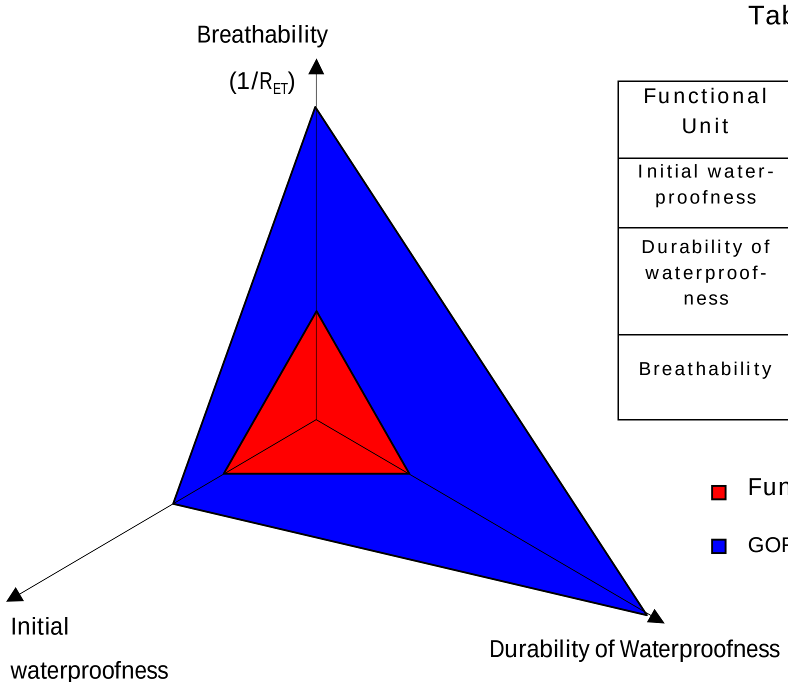
A functional unit is a measure of the service delivered by the product. For this study, the functional unit was defined as: “The use of a single windproof, waterproof and breathable outdoor garment during five years.”

This is to provide 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.

The jacket is assumed to be separately washed, re-impregnated and tumbled twice a year, and last five years, while continually fulfilling the minimum performance criteria described in Table 1.

Table 1

Functional Unit	Lightweight Mountain Sports Jacket	
Initial water-proofness	> 1,4 bar	Based on DIN EN ISO 20811
Durability of waterproof-ness	> 100 h	Hours of wet flex and abrasion strain until water penetration occurs at 0,7 m water column
Breathability	Ret < 13 m²Pa/W	According to ISO 11092 (identical to DIN EN 31092).



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 windproof, waterproof and breathable “all-rounder” mountain sports jacket.

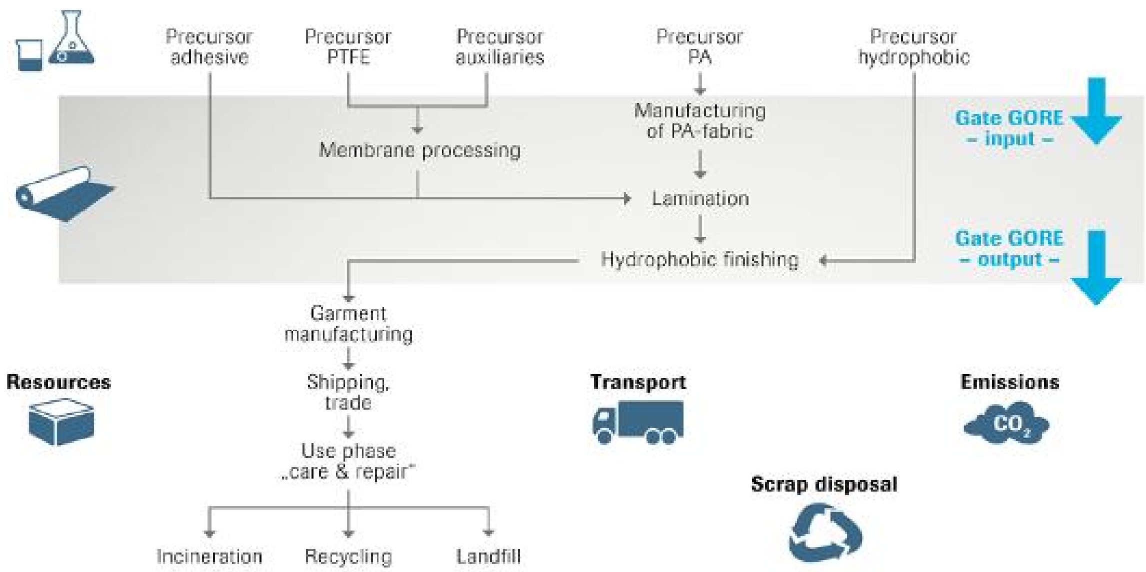
4 SCOPE AND ASSUMPTIONS

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 live cycle, from “cradle to grave”.

This includes the upstream processes, such as adhesive, PTFE, auxiliaries, polyamide and the hydrophobic treatment. These materials enter the Gore manufacturing plants, where the ePTFE-membrane processing takes place. In the next step, “DWR” (Durable Water Repellent) is applied and textiles are laminated to Gore membranes, before they leave the Gore factory.

After the garment has been manufactured in Indonesia it is packed and distributed via a Californian distribution hub to US consumers. Transport is assumed to take place by overland or ship transport (90%) and air transport (10%). The consumer trip to a retailer was estimated as a single 10 km return trip in an average car.

After a five year use phase the garment is assumed to end up in a landfill in the US. Over this period of time, the jacket is assumed to be cared for twice a year with a separate wash, re-impregnation (water repellent treatment through the consumer) and tumbling. Standard home laundry, detergent and energy mix for the US were used.



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 outerwear is not readily available. An analysis of complaints received by the GORE consumer hotline indicates an average, across the product range of GORE-TEX® branded apparel products, of five and a half years up to the time of the first complaint. The five years life time assumed for this study is therefore a conservative assumption for GORE-TEX® consumer garments. This is also true for the washing frequency and the fact that the jacket is assumed to be washed separately. A cautious approach was also taken by assuming that the consumer applies a DWR retreatment after every wash. It does not take into account that Gore's factory applied DWR can be regenerated several times after washing before a spray on is necessary.

It must be noted though, that a real life scenario with a shorter or longer lifetime depending on the usage frequency, fewer or more washes and a jacket being washed together with other laundry could change the outlook of the results.

5 RESULTS

Over the entire lifetime - from cradle to grave – of an all round GORE-TEX® waterproof, windproof and breathable jacket a total of 72.7 kg of CO_2-eq. are emitted, 2.08 m^3 fresh water and 992 MJ of primary energy are consumed.

Detailed ReCiPe Midpoint (H) results:

Name	Acronym	Unit	Result
climate change	GWP100	kg CO2-eq	72.7
ozone depletion	ODPinf	kg CFC-11-eq	9.27e-5
terrestrial ecotoxicity	TETPinf	kg 1,4-DCB	5.37e-3
terrestrial acidification	TAP100	kg SO2-eq	0.363
freshwater ecotoxicity	FETPinf	kg 1,4-DCB	0.092
freshwater eutrophication	FEP	kg P-eq	0.020
marine eutrophication	MEP	kg N-eq	0.118
marine ecotoxicity	METPinf	kg 1,4-DCB	0.053
human toxicity	HTPinf	kg 1,4-DB-eq	4.33
photochemical oxidant formation	POFP	kg NMVOC	0.19
particular matter formation	PMFP	kg PM10-eq	0.10
ionising radiation	IRP_HE	kg U235-eq	1.32
metal depletion	MDP	kg Fe-eq	1.33
water depletion	WDP	m^3	2.08
fossil depletion	FDP	kg oil-eq	19.2
agricultural land occupation	ALOP	m^2a	0.88
urban land occupation	ULOP	m^2a	0.50
natural land transformation	NLTP	m^2	0.0075

Assessing the contributions that single stages of the life cycle have on the overall impact values shows consistent results for most impact categories: Consumer care, textile supply chain, distribution and Gore processes (which include the PTFE supply chain) are impactful while the disposal has a negligible impact. Only water depletion shows a different picture: Water is predominantly consumed during consumer use. The textile supply chain also has an influence, albeit minor, and the impact of all other stages is negligible for this indicator.

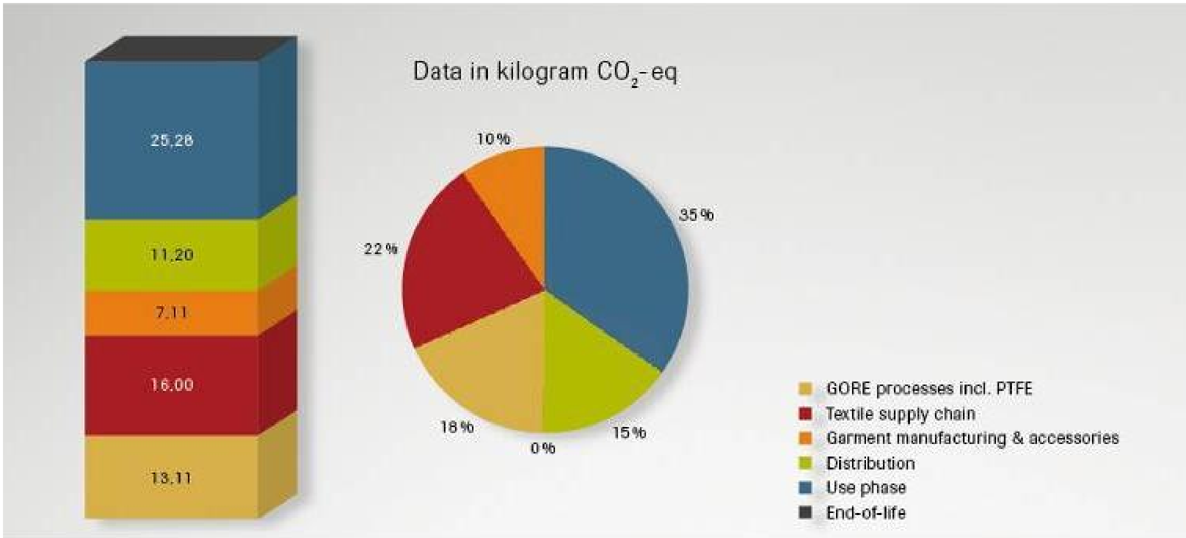
6 CONCLUSIONS

Based on these results, the main findings of this study can be summarised as follows:

- The jacket's production and distribution have an important impact: 65% of Global Warming Potential (GWP).
- The impact of longevity on the annual ecological impact is such that the jacket's life time is the single most influential parameter for improving several environmental impacts
- Consumer care has a strong influence on a jacket's overall impact: 35% of GWP.
- End of life has a negligible impact compared to other stages; less than 0.1% of GWP.

6.1 Production and distribution

The jacket's production (Gore processes incl. PTFE, textile supply chain, garment manufacturing and accessories) and distribution have an important impact (65% of GWP).



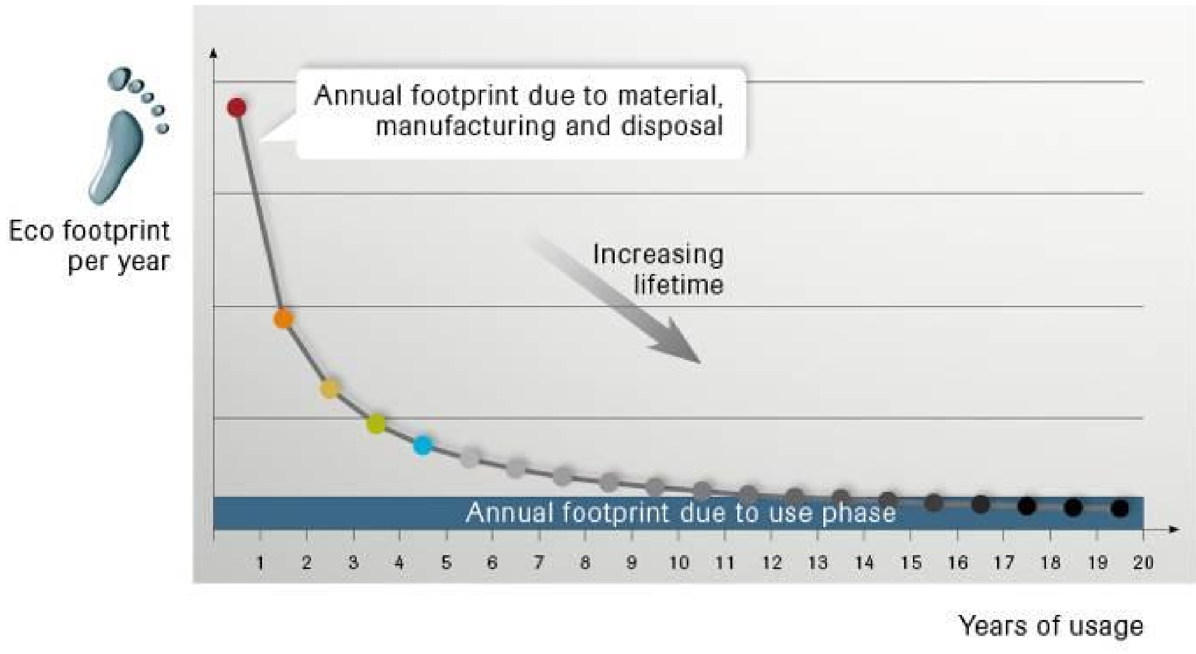
The global warming (GWP) and marine eutrophication (MEP) indicators highlight that transportation can have a significant influence, but much of this lies outside of Gore's direct control. Therefore engaging with upstream suppliers and brand customers is a prerequisite to improve GORE-TEX® garments' environmental performance. A good example is the planning and orchestration of material transports along the value chain since products are only produced when ordered by the retailer, triggering all upstream activities.

Textile production and the manufacturing of the jacket also appear as significant contributors to GWP. But even though much of this lies outside of Gore's direct control, Gore potentially has the opportunity to influence this; through cooperation with the upstream and downstream textile supply chain and also through its choice of fabrics for GORE-TEX® laminates.

6.2 Longevity

Focusing on longevity enabled Gore to identify that the impact of longevity on the annual ecological impact was such that the jacket's life time was the single most influential parameter for improving several environmental impacts.

In other words: The longer a jacket lasts, the smaller its annual environmental impact will be.



6.3 Consumer care

Consumer care has a strong influence on a jacket's overall impact. In the light of this information, engaging with consumers to promote the right type and frequency of care appears as an effective way to improve on that specific area. And this is true whatever the washing scenario.

Scenario	**1 Base line**	**2 Short life-time**	**3 Long life-time**	**4 Best case**	**5 Good compromise**	**6 Less washing**	**7 More frequent washing**	**8 Higher washing load**	**9 More air transport**
Life time	5 years	3 years	7 years	7 years	7 years	5 years	5 years	5 years	5 years
Annual washing cycles	2	2	2	2	3	1	3	2	2
Washing machine load	1 jacket	1 jacket	1 Jacket	2 jackets	2 jackets	1 jacket	1 jacket	2 jackets	1 Jacket
Overseas air freight percentage	10%	10%	10%	10%	10%	10%	10%	10%	50%

Table 2: Overview of different wash scenarios calculated

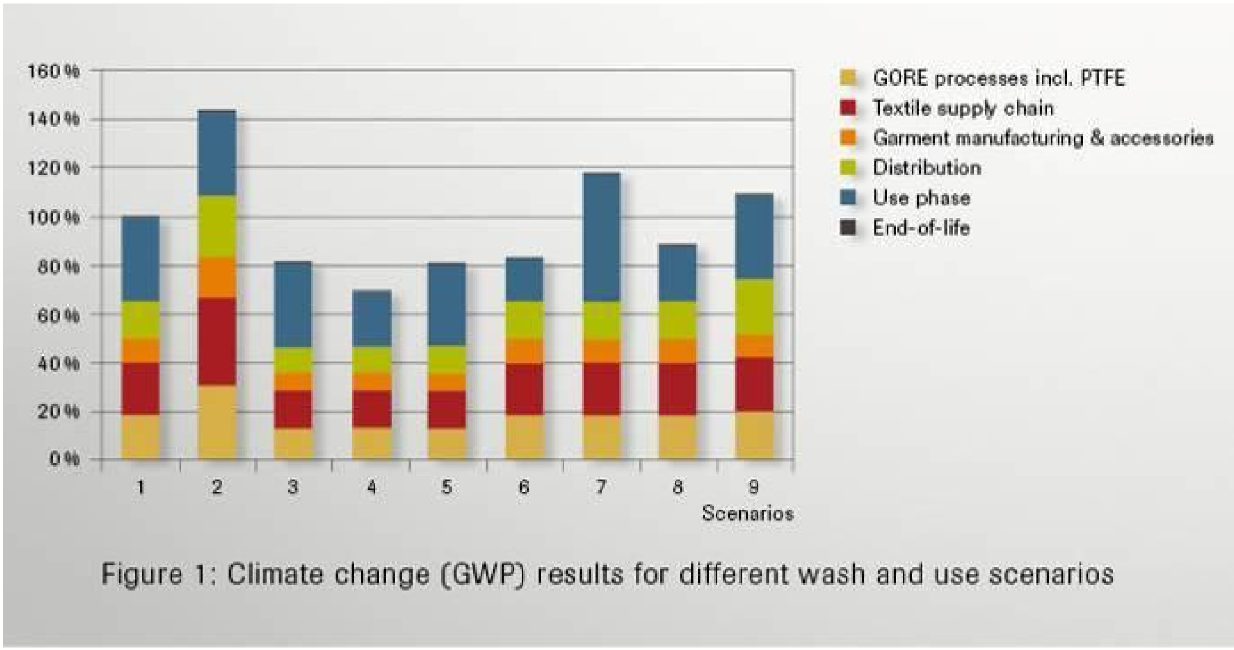


Figure 1: Climate change (GWP) results for different wash scenarios

7 RECOMMENDATIONS

The study's results show that, both in the manufacturing process and in the consumer care stage, it is possible to reduce the product's environmental impact. Here are a few recommendations:

7.1 PRODUCTION AND DISTRIBUTION

- Air freight of raw materials increase the GWP compared with sea or ground transportation
- Flying further upstream produced materials or even the final product typically coincides with less efficient packaging and therefore an even larger GWP
- Thorough planning and time buffers help avoid air transports
- Increased transport and packing efficiency would further reduce GWP and costs
- The use of fossil energy sources in production processes is a large contributor to the product's GWP impact
- A reduction in the amount of energy used, and/or the use of renewable energy in the production and manufacturing processes will lead to a direct reduction of the jacket's environmental impact

7.2 CONSUMER CARE

- Wash, when dirt and body oils have soiled the jacket. Washing will maintain breathability and extend the useful life of the jacket
- Add the jacket to a load of other, if possible lightly soiled, textiles following the care instructions
- Retreat the DWR only when the water repellency cannot be restored by tumbling or ironing the dry jacket after wash
- Use the Gore approved fabric repair kits and repair centres to further extend the jacket's lifetime

But this also implies that Gore, and by association outdoor apparel brands, have an important part to play in educating customers as to the right amount of care needed to guarantee a jacket's performance and durability.

7.3 LONGEVITY

- Small changes in durability have a significant influence on the annual footprint.
- Higher "ecological-costs" during material provision and manufacturing – e. g. for an abrasion resistant outer shell textile or a more durable barrier technology – can easily be compensated by a longer life time of the final product.
- A long useful lifetime is essential to minimize the annual footprint.