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Pulling Wool over our Eyes: The Dirty Business of LCAs

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Abstract
Eco-credentials are becoming an important factor in the quest for customers and profit: Thus different assessments of the environmental impact of a fiber not only show off the eco-footprint, energy- or water-use; but also becomes a positioning-tool in the market-place.

When Dutch “Made-By” launched their benchmark assessment of fibers, it created quite a stir as it was one of the first attempts to do an international over-all quantified eco-ranking to be used by designers, manufacturers and consumers. H&M, among others, quickly adopted it as a guide in sourcing, but critical voices emerged - especially when it was unearthed that the assessment was limited up until spinning. This fact was not clearly communicated and created a picture where wool was ranked in the dunce class alongside conventional cotton.

This is one recent example of how good intentions can cause confusion when not communicated clearly, and illustrates the complexity of Life Cycle Assessments.

The European and American Outdoor Groups Eco-Index and Colour Connections Eco-metrics offer qualitative eco-indicator guides based on life cycle data, with the aim to assist designers, manufacturers and consumers in their decision makings.

This paper addresses the growing competition for being the most “eco-friendly” fiber. It discusses whether LCA is an adequate tool for comparing fibers and textiles, and compares traditional Life Cycle Analyses with the Cradle-to-Cradle Life Cycle Development. Further it looks at different Life Cycle Analysis and tools that have attempted to rank and judge fibers and textiles, and addresses the challenges in communicating complex facts to the market.

Summary

Life Cycle Analyses (LCA) has been an available tool in industry for 20 years, but has not developed into a widely used tool for decision making in companies. It is dependent on specific scientific competence and data tools and is not a convenient tool for designers and small companies. Most LCAs are being used to compare the negative environmental impact of products or services, not as basis for improvements and new designs. There are big differences in individual company performance throughout the industry that is not visible in LCA since they are mainly performed with global data and industry average.
The scientific world of LCA includes disagreements on metrics, allocation rules and weightings, and confusing people by nontransparent or not complete assessments.

A textile fiber as raw material represents the first stage of a product`s life cycle and must be further processed to become a product. If conducting an LCA only of the fiber, most of the intended product life and impact is lacking and the LCA becomes a narrow, fragmented study. The single stage analyses has the risk of misguiding users as being a complete answer, if not communicated very clearly.

The clothing industry is both fast consuming fashion and long term classics. The ecological impacts are dependent just as much on life time, use and end-of-life solutions as it is on material choice and manufacturing. Therefore it must be designed in a complete life cycle perspective, and choosing the material related to function, esthetics, expected life time, care and end-of-life.

Designers have the power and possibilities to change negative ecological footprints of fashion and textile industry to creating value for both people and planet. Harmful chemicals can be excluded in the products from the beginning, and plans for the material`s afterlife and recycling been included in the design process. In combination with a change in consumer behavior, made by focusing on quality and preventing businesses push cheap clothing into the market in fast consuming fashion cycles.

Future focus must be on improvement, innovation and design in a never ending dynamic process. If we do things right at the beginning we will need LCA only as inventory tool, since impact is designed to be positive.

The textile Industry has started to develop and share design tools that are holistic, easy to use and communicative. This is very welcome in a complex global industry with huge negative environmental impacts. These tools will contribute to continuous improvements of ecological performance from clothing throughout their complete life cycles and serve the market with transparent information.

We believe near future will provide us with more useful and easy- to- use Life Cycle based Design tools to assist industry and business in design, manufacturing and purchasing of products. As industry continues to build coalitions to cooperate, this will become a strong tool for ecological improvement and sustainable growth on a larger scale.

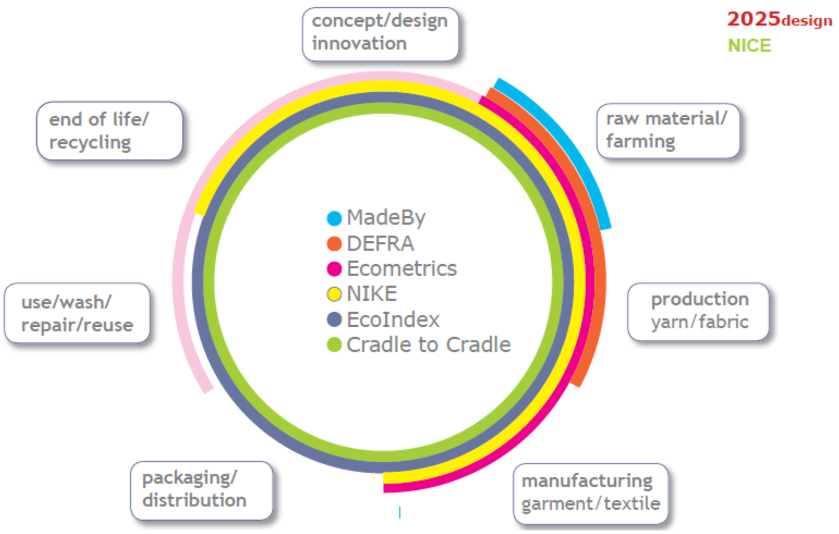
Assessment and design tools

Several tools have emerged during the last year in order to assist decision makings in textile design, purchasing and manufacturing. They are all based upon Life Cycle thinking, still quite different in content and approach. There is a need for assistance to clarify differences and possibilities.

This paper takes a closer look at MadeBy Fiber Benchmark , the DEFRA Study, Ecometrics, the NIKE Design tool, EcoIndex and Cradle to Cradle Life Cycle Development.

MadeBy's[1] benchmark assessment tool is a Life Cycle Analyses assessing different fibers up to spinning. The DEFRA[2] Study goes one step further up to fabric production. In this paper we have mainly looked at the DEFRA Study's fiber-comparison, pitting it against MadeBy. These two are inventory and impact assessments only, providing facts and figures.

The Outdoor Industry Association's[3] Eco-Index and NIKE's Design tool are both design tools. EcoIndex is an indicator guide based on life cycle thinking, while NIKE's is LCA data based. Colour Connection's[4] Eco-metrics is an impact assessment and decision-making calculator tool based on life cycle data. Cradle to Cradle Life Cycle Development is a development and design method based upon life cycle inventory and focusing on improvement in the life cycle through design.
These have the aim to assist designers, manufacturers and consumers in their decision-making. They are inventory-, impact- and improvement-tools.



Different assessments and tools cover different parts of a textile product Life Cycle. (Ill.by 2025design)

[1] MadeBy is a Dutch organization which among other things has developed a track and trace system for clothing.
[2] The British Department of Environment, Food and Rural Affairs has an ongoing Clothing Roadmap where this study is a part of the work being done.
[3] Formed by the European and American Outdoor Associations.
[4] A British Consultancy working with major brands on improving their eco-imprint, specializing on production in the Far East.

Life Cycle Assessments of fibers and textiles

Conducting an LCA is complex and complicated, and results depend on a huge amount of different factors and uncertainties. To a certain extent you may get the result you ask for: an LCA can be manipulated within acceptable methodological limits to give a desired result. An LCA is expensive and time consuming to conduct, hence it is not the most appropriate tool for small companies or individuals.

Methodology
A Life Cycle Analysis (LCA) as regulated in ISO 14040-43 consists of three main stages; the goal and scope of the study, the Life Cycle Inventory (LCI) and the Life Cycle Assessment (LCA).
The first main choice when conducting an LCA is whether to include the complete life cycle of a given product or service, or only certain stages. The **life cycle** of a product is all the activities utilized in extraction of raw materials, design and formulation, production, processing, packaging, transportation, use and disposal of a product (European Environment Agency, 1997). It is not unusual to do an LCA for only a few stages. **System Boundaries** define what is included and not, for example whether the materials for the tractor used to harvest the grass for the sheep is included, or whether the possible recycling of used garment is counted for. The **Functional unit** describes what function is to be assessed, and must be measurable. For example one cotton T-shirt washed 20 times, or two years' supply of woolen socks for one person.

Impact categories
According to the Life Cycle Impact Assessment standard ISO 14042, there are three broad groups of impact categories that should be taken into account when defining the scope of an LCA study.
They are commonly referred to as AoPs[5] (Udo de Haes et al., 1999):

- Resource use
- Human health consequences
- Ecological consequences

The quality of an LCA is dependent on its input and on those who interpret it. Crucial issues are:

1. Data quality; reliability, accuracy, site specific or generic data,
2. How system boundaries, weightings, impact categories, cut-offs and functional unit are chosen and defined.
3. Interpretation and evaluation of findings
4. Communication of the findings

Gaps in data collection or differences in **allocation** and aggregation procedures can limit the quality of results (Milà i Canals, 2003; AS/NZS ISO 14042:2001).

After conducting an analysis and impact assessment, the issue remains how the framework and results are to be communicated effectively.

One major choice that influences the result of the LCA, is whether to use site-specific data or literature-based, generic data. Site-specific data give exact facts about the product from one specific supplier or supply chain. This is useful for companies if they want to show an individual environmental performance. Generic literature based data are used to paint a picture of a product or an industry in general, as an average. The next question is: which data or database-tool is used, and what input does it rely on? European, US or global data? Specific or generic?

[5] Areas of protection

A lot of textiles are manufactured in Asia, still there is hardly any data available from Asian industry and manufacturing. Which leaves us to assumptions and approximate data, for instance we can use “worst-case” European data to simulate Chinese data; for example CO_2 emissions per transported unit from a large truck in China may be judged as equal to a small truck in Europe, because of the assumed technical state of Chinese vehicles and fuels. Considering what we know about working-conditions in Asia, and lack of pollution-control of water, land and air, this is probably the biggest void in knowledge of real impacts we have. This has not been addressed in any study so far. Since large amounts of textiles are manufactured in Asian low-cost countries it is a weak point in all LCA that we lack a lot of real facts and life cycle data on impacts from this industry.

LCA is a snapshot of a given situation, stating facts. It is up to the user to understand how to utilize this information as a basis for improvements - and if to, alongside making good decisions based upon scientific evidence. An LCA is dependent on its input, whoever interprets it, and the communication of findings.

A few general remarks on LCA for textiles from the DEFRA Study

- In a wider perspective, studies should take account of the durability and lifetime of apparel products (including end of life use or re-use)….
- LCA studies should for example ensure allocation of appropriate environmental burden sharing to co-products of natural fiber production to enable more appropriate comparisons…
- There is a further need to agree on approaches to balance or weight different environmental impacts in a meaningful way for the textile industry so more simplified eco-ratings can be developed for textiles and textile fibers.

MadeBy Benchmark tool www.made-by.org

The MadeBy Benchmark tool is an example of how if the parameters of a given LCA are not understood, used and communicated correctly, a certain amount of chaos will ensue. This assessment compares the most common fibers from raw material production up to the spinning of yarn. This means comparing the non-renewable fossil resource use for making polyester with the growing of cotton and sheep farming for wool. It does not address the textile production processes; chemicals, waste, pollution, wash and disposal of garments. Only few users in the textile design and industry have the knowledge of LCA methodology, and they will easily be misguided as long as the accompanying instruction-document is not spread or read.

MADE-BY's Environmental Benchmark for Fibres

Fashion with respect for people and planet
www.made-by.org

CLASS A	CLASS B	CLASS C	CLASS D	CLASS E	UNCLASSIFIED
Recycled Cotton	Tencel® (Lenzing Lyocell Product)	Conventional Hemp	Virgin Polyester	Conventional Cotton	Silk
Recycled Nylon	Organic Cotton	Ramie	Poly-acrylic	Virgin Nylon6	Organic Wool
Recycled Polyester	In Conversion Cotton	PLA	Lenzing Modal® (Viscose Product)	Rayon Cuprammonium	Leather
Organic Hemp		Conventional Flax (Linen)		Bamboo Viscose	Elasthan (Spandex)
Organic Flax (Linen)				Wool	Acetate
				Generic Viscose	Cashmere Wool
					Alpaca Wool
					Mohair Wool
					Fibre-based Bamboo

These Benchmarks cannot be printed, circulated or copied without the accompanying MADE-BY Logo and Website.

The first impression is that wool and conventional cotton are “bad” fibers and recycled polyester and organic cotton “good” fibers. Of course recycled fibers are the “best” fibers because energy use is reduced substantially when recycled compared to production of virgin fiber. This sounds like an easy rule to follow but there are other consequences that do not compute easily when the assessment is based on the "truth" that all fibers after spinning are more or less the same, thus not addressing the holistic view of a complete life cycle and not considering different functions, use, life time and consumer-behavior.

Then the question arises: Why does an organization like MadeBy make a choice with such dire consequences for some fibers? Is it lack of input? Is it lack of understanding of the complexity in the entire LCA? Is it a question of over-simplifying in order to please the consumer? Or is this a case of wolf in sheep's clothing, trying to manipulate the results to someone's advantage?

DEFRA[6]

The fiber comparison in the DEFRA Study shows more or less the same as the MadeBy assessment. This study is based upon broad literature studies of LCA of fibers and textiles

DEFRA Study : The role and business case for existing and emerging fibres in sustainable clothing, 2009

Fibre	Relative impacts between fibres (+ = relatively low impacts, ++++ = relatively high impact)					
	Energy use	Water use	GHG emissions	Waste water production	Chemical use	Land requirement
Acrylic	+++	++	(+++)	+++	(++ - +++)	N/A
Bamboo	(++)	(+++)	(+)	(++)	(++ - +++)	(++)
Cotton (conv. organic)	++	++++	++	++	+++	+++
Flax	+	+	(++)	(++)	(+++)	+++
Hemp	+	++	(++)	(++)	(+++)	++ - +++
Jute	ID	ID	(++)	(++)	(+++)	++
Lyocell	++	++	+	(++)	(++ - +++)	+
Modal	++	+++	(+)	(++)	(++ - +++)	++
Nettle	(+)	+	(++)	(++)	(+++)	+++
Nylon	+++	+++	++++	+	(+ - ++)	N/A
PLA	++	(+)	++	ID	(+ - ++)	+
Polyester	++	+	+++	+	+ - ++	N/A
PTT	++	+	+++	(+)	(+ - ++)	(+)
Ramie	ID	ID	(++)	(++)	(+++)	++++
Silk	ID	+++	ID	(++)	ID	ID
Soybean	ID	ID	ID	(+++)	(++-+++)	ID
Spanish broom	ID	+	(++)	(++)	(+++)	ID
Viscose	++	+++	+	(++)	++-+++	++
Wool	+	+	ID	++++	++-+++	++++

ID = insufficient data, NA = not applicable, Figures in brackets based on use of information from similar fiber typesFrom: Turley, D. B., Horne, M., Blackburn, R. S., Stott E., Laybourn, S. R., Copeland, J. E, and Harwood, J. 2009.

[6] Department for Rural Affairs, UK

Literature and other sources of information were collated to identify the environmental impacts of each fiber supply chain, from raw material production to factory gate for the above fibers. Data on energy use (indirect and direct) and water use for each phase of the chain was collated where available. Information on other impacts (greenhouse gas emissions, waste water emissions) was much more limited. Other impacts, such as land use demands for non-synthetic fibres, were calculated from the available data.

Any LCA on fiber up to spinning will reach the same conclusion and point to the same "bad guys"; Cotton will always be the water-consumer, wool the land-consumer and polyester the non-renewable consumer.

Comparing products

LCA is often used to compare products with each other. Therefore it is necessary to consider the whole life cycle, from cradle to grave, or cradle, in order to get a real picture of impacts and the real comparisons of products and services. An analysis that looks only at one or a few stages can be done as well, but must be clearly communicated and treated as such.

The European Environmental Agency [7] recommends that LCAs are not used to claim a product or service is environmentally friendly or superior to another. It is possible to claim that using a specified set of criteria, one product is better than another in certain aspects of its performance. However if making such claims it is very important that accurate data and unbiased information is used, the assessment has been peer reviewed, and not to over-claim.

Assessing natural fibers in LCA – the example of wool

Wool (and other natural fibers) has some main impacts that are hard to get around; mainly water-use and land-use.

Both in the MadeBy and the DEFRA study the use of land is the main impact category that gives wool a bad score. All fibers can easily be judged on how many acres are needed for 1 kg fiber. The main issue is to know what kind of land-impacts are in question. Land-use as such is not equivalent to negative impact. Taking land away from food production or transforming rain forest into a cotton-field represents a negative impact, but letting sheep graze in non-arable areas such as mountains or overgrown landscapes represent a positive and necessary impact for the environment, even if large areas are used. Modern agriculture exploits nature, and the soil has lost the natural content of humus that makes it able to catch large amounts of CO_2, which is one of nature's best "carbon-banks". Sheep farming in its most basic form, where nature equals food and sheep-poo is left wherever it falls, ensures that sheep grazing on non-arable land contributes to maintaining a healthy soil and natural CO2 storage.

A lot also depends on the agricultural system, the individual farm, how water, energy and land are managed. This of course varies in different countries, regions and even on a local scale one may find significant differences in farm management and techniques used. Hence the results are more exact the more site-specific the data is. There is no common consensus within research on how to deal with different agricultural aspects in LCA like allocation rules, greenhouse gas emissions, energy use etc.

LCA was made for industrial systems, not for natural systems. Nature cannot easily be put into metrics in the same way as activity in an industrial site can be measured, where inputs and outputs are more easily monitored.

[7] European Environmental Agency, EEA, 1997

If the world was according to LCA, cows and sheep would be banned, and battery hens would be the best option, all because the metrics say so.

"As with all agricultural products the numbers vary greatly based on the system. So a wool from more arid regions of Australia will be significantly different than a wool from England."
Eric Williams, Brown and Williams[8]

So far no LCA on global wool has been publically available. Choosing a global wool study of one kilo instead of local studies like the one conduced in New Zealand[9], is comparable to the difference between a full color palette and mixing all colors in the palette so everything becomes brownish grey.
Wool from sheep is best evaluated as a regional or local raw material with different profiles; this is supported by all LCA literature found on wool and textiles. Diversity should be appreciated and the strengths of each region and each fiber should be highlighted, rather than watered out by world-averages. The advantage of positive local or other qualities and impacts, the fact of "doing good" should also be communicated.
To get wool out of the "dunce" position one must compare the complete life cycles of fibers, including the areas of positive impacts. This includes, in the case of wool, use and reuse, airing vs frequent washing, natural fire-retarding, moisture-absorbance, and the ability to keep us warm when it is cold and cool when it is hot. This is not part of a classic LCA, but possible if conducting a Cradle to Cradle evaluation and Life Cycle Development.
Wool could, in theory, be made with virtually hardly any negative impacts. It grows on rain water and grass, and is a by-product of meat-, milk- and lanolin-production. Wool aids landscaping. By replacing pesticides and process-chemicals with those proven to be compatible with nature, animal and human health, by ensuring clean waste-water and using renewable energy both for farming and processing – wool is suddenly no longer a "dunce". Designing for a long life-span, reuse and recycling further enhances wool's eco-profile, by creating qualities that will be loved and cared for, even through generations.

"When conducting an LCA on wool, it is necessary to do the study on the specific country, or several countries/regions, where the wool comes from to cover a representative choice of global production."
J. Pettersen, MISA[10]

Challenges in comparing different fibers and textiles

To compare natural fibers with synthetic fibers is more complex than it seems. It is nature versus industry, renewables versus non-renewables.

Any comparison of fibers is only fair if we consider the whole life cycle of a given garment, and include all life cycles of the material throughout use, reuse and the potential for recycling. Fibers and textiles have different qualities, strengths and weaknesses. When comparing different fibers it is necessary to consider that they are different products with different production-processes, uses and maintenance.
One product might have huge emissions in the raw-material phase, others in the user-phase. Polyester has high CO_2 emissions in the raw-material phase, but uses less dyestuff than other fibers and is excellent for material recycling. Wool grows on grass and rainwater, but has large effluent-

[8] Quote from an e-mail dialogue with *Eric Williams, Brown and Williams, USA, 2011, LCA consultants for MadeBy and NIKE*
[9] Barber and Pellow, 2006
[10] MISA, Environmental Systems Analyses, Trondheim Norway, 2011

water impact when scoured, but requires less washing in the user-phase. One impact can be balanced by another.

Weighting

Weighting of different impact categories and indicators is handled different by each actor, making it more complicated to compare results.
MadeBy has given Green House Gases (GHG) and toxics the highest impact weighting, and energy, water and land use less. In comparison NIKE has chosen a different impact-key with toxics as the highest followed by Greenhouse Gases and energy use. Ecometrics has a non-transparent weighting key, translated into Environmental Damage Units (EDU). (see Figure 3)

	Assessments		Impact	Design tools		LCD
Impact Categories Indicators Weightings (nr/%)	DEFRA Study	MadeBy BM tool	Eco metrics	NIKE	EcoIndex	Cradle to Cradle
Land use		13,3,%		8		
Energy use (vol)		13,3 %		12		
Energy source						
Water use (vol)		13,3%		8		
Waste Water						
GHG		20%		12		
Eco Toxics		20%				
Human Toxics		20%		40		
Chemical use (vol)					RSL	
Pollution						
Waste (physical)				7		
Recycled content				6		
Non-/Renewables						
Material efficiency						
Source certification						
Design for life time						
Design for end of life						
End of life scenarios				7		

Figure 3; Impact categories, indicators and weighting (Ill. 2025design)

In the end it is impossible to compare apples with pears, and a challenge to judge the different stages up against each other. How to weight the significance and impact-importance of CO_2 from production, against heavy-metals in the dyeing process, against the energy-consumption of the washing machine? All negative impacts are important to assess, and yet they are very different.

The different assessment and design tools available have chosen different weighting models and environmental impact categories. This gives different results with the different tools for the same fiber or product. It is difficult for others than the tool-owner to use a company specific rating that is related to internal policies and strategies, since this is not transferable as a generic tool suitable for any other company. Without knowing or sharing the priorities set and the methods used there is a fair chance of misunderstanding, misinterpreting and generally misleading others. And still there is no right or wrong in how to conduct this weighting. NIKE`s tool has weighting based on their internal policies and strategies, which makes it right for them, but not necessarily right for any other company unless they adapt the same policies. Hence equal weighting as NIKE is considering could be discussed.

Design tools

"It's pretty tedious and difficult to conduct a full LCA for even one product. And when you're done, it says "Oh, here's the impact of your product used and disposed of in a certain way." Trouble is, that doesn't reduce anything; it just tells you how bad it is".
US Designer Steve Eppmann[11]

To perform a detailed life cycle assessment before starting to make improvement and redesign is an expensive and slow way to make change. Rather than a complete and detailed LCA it may be more useful to conduct a qualitative assessment of a given product, since the main impacts are normally easy to detect. This would give a better understanding of the improvement possibilities.

It is widely accepted today that future environmental impacts are invented in the innovation and design phase, and that this is where they must be addressed. Designers and product developers have huge responsibility, but also a lot of possibilities to make good products.
Hence it is important to include design and innovation thinking into LCA processes and methodology. LCA should focus more on the improvement phase, in order to help speed up the environmental improvements we need, not only in the textile industry. Design tools like NIKE's and EcoIndex, along with Cradle to Cradle Design, are promising approaches that can make positive improvements and better environmental choices more easily available for everyone. Tools must be easy to use and easy to understand for all decision makers, not only for specialists.

EcoMetrics

Ecometrics[12] was developed by Phil Patterson at UK`s Colour Connections. The tool was released in 2009. EcoMetrics is an on-line calculator that enables one to compare the environmental impacts of different textile products and processes up-stream and down-stream.
EcoMetrics is the only tool to look at reduced textile consumption and product durability.
Colour Connections aim to use EcoMetrics to educate and point out some very obvious problems and opportunities rather than getting bogged down in an academic debate about mathematics.

Plans exist to develop the tool to include fabric blends and to look at real world scenarios, e.g. where you can compare a cotton product dyed in a good dye-house with one dyed in a dye-house with a bad eco-profile.

Fig. Screenshots from EcoMetrics; Calculator and Result examples for wool and cotton

EcoMetrics looks at *<u>impacts</u>* *and not just usage, so the tool would consider a factory with solar panels and wind turbines to be low impact even if their energy usage was high. Likewise with wool it looks at the impacts – the land use is high but what else would the land be used for? If sheep were raised on*

[11] MIT Sloan Management Review, Interview October 2010
[12] www.colour-connections.com/EcoMetrics

prime agricultural land the impact would be much higher, but they are raised on mountains where nothing else can be grown. (Phil Patterson[13])

Nike Environmental Apparel Design Tool

The Nike Environmental Apparel Design Tool[14] serves as functional calculator with the ability to measure the impact of materials commonly used in manufacturing apparel products. The Tool evaluates waste, energy, toxics and water in materials and manufacturing, enabling NIKE to influence the most significant components of a product's environmental impact.
The tool takes a pragmatic, strategic life cycle management approach where sustainability is viewed as a journey rather than a static measurement of impacts. The use of product scores and labels such as Gold, Silver and Bronze for scoring and communication helps to simplify a complex task, making sustainability concrete enough to bring designers on board, giving them the information and incentives to make a real impact through design choices.

NIKE discusses some important issues and challenges related to weighting of impacts:
"When we began work on our materials tool, we wrestled with tough environmental questions regarding environmental tradeoffs. For example, how should we evaluate the impacts of water intensity with CO2 emissions with carcinogenicity? The impact weighting in this version of the tool reflects Nike values when we first developed it in 2008. At that time, chemistry was given 40% of the overall weight, energy/CO2 24%, waste 20%, and water/land 16%. Over the past year, Nike's Considered Team has determined that there is no industry consensus or standard point of view regarding the relative weighting of environmental impact area. For that reason we have drafted a new version of MAT with revised weighting, framework, impact metrics, and MAT data methodology. One of the key changes will be in MAT v2.0 is equally weighting each impact area – energy/CO2, water/land, waste, and chemistry are all worth 25% of the total possible points". [15]

EcoIndex

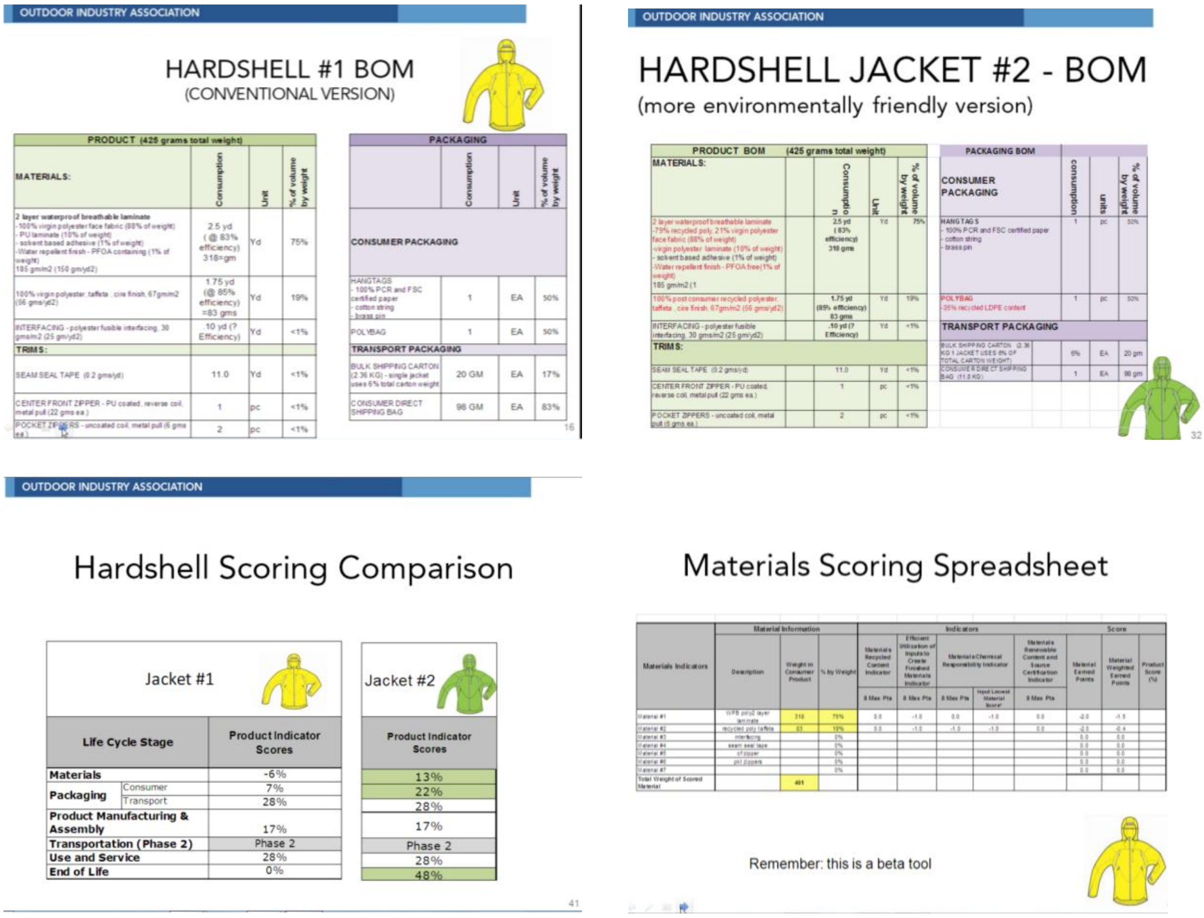
This Ecoindex[16] is developed by the Outdoor Industry Assosiation. It is a tool for development and evaluation of complete garments and products, including packaging. It is based upon life cycle thinking for complete products. While the long-term goal is a data-driven life cycle evaluation there is little to no data yet collected. The current approach uses indicators. It rates one piece of garment and packaging, not the fiber as such, and makes it easy to compare with other similar products. This makes it a very practical tool for designers and manufacturers. It has a positive focus of preferable inputs.

The Eco Index is designed to help determine how the industry measures its environmental footprint throughout the supply chain, involving five of the six product life cycle stages: Materials, Packaging, Product Manufacturing and Assembly, Use and Service, and End of Life. Measurement tools within the areas of water, waste, and energy use/greenhouse gas emissions have also been developed.
The indicators used are among many; recycled content, renewable content, organic cotton, responsible chemical use, source certification, and design for recyclability.

The products are declared in Bills of Material (BOM) with weight and volume of the different fibers, weighted according to possible qualitative environmental impact, and added up to indicators for the different products.

[13] *Quote: Phil Patterson, Colour Connections, 2011*
[14] http://www.nikebiz.com/responsibility/nikeenvironmentaldesigntool

[16] www.europeanoutdoorgroup.com



This comparison method is an easy way to visualize different impact results from different material and design choices made in the idea phase, helping the designer make the best choice. It points out the main challenging areas and dilemmas for choice. It is simply a good tool.
A main focus in this tool is the Design for a product`s Life time through repair and service etc. and Design for End of Life and recycling, including management policies and plans.

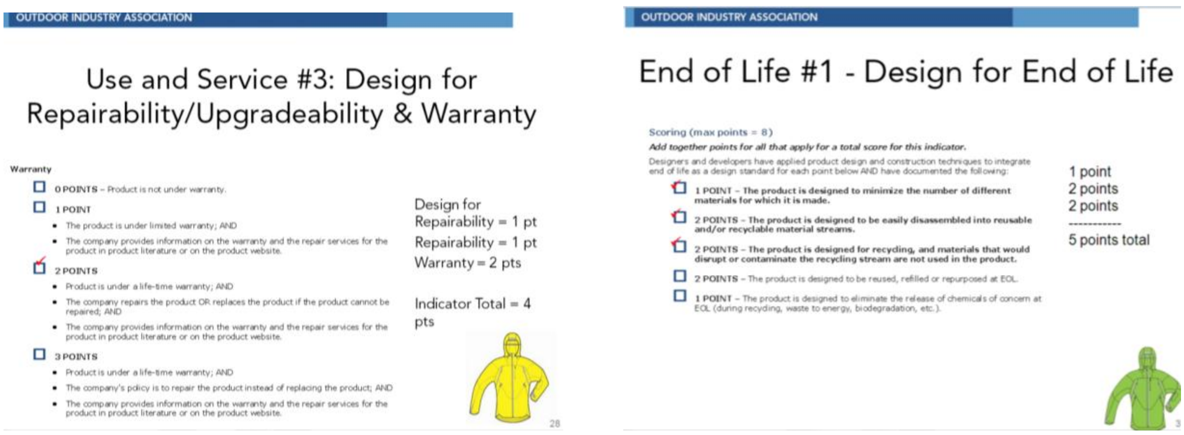


Fig Examples from EcoIndex work sheets;
1: Score card for material composition in jacket,   2: Design criteria for a prolonged garment life

The Sustainable Apparel Coalition – Version 2 Apparel Index

A group of leading apparel and footwear brands, retailers, manufacturers, non-governmental organizations (NGOs), academic experts, and the U.S. Environmental Protection Agency have launched the Sustainable Apparel Coalition.
The goal of the Coalition is to lead the industry toward a shared vision of sustainability built on an industry-wide index for businesses to use to measure and evaluate apparel and footwear product sustainability performance. The tools will be developed with involvement of a wide range of stakeholders, and the metrics will be fully transparent to encourage broad adoption of the index globally. To accomplish this, the Coalition will draw on the work from different efforts to measure and track apparel sustainability including the Outdoor Industry Association "Eco Index" and Nike's "Environmental Apparel Design" tools.
Starting out as internal design and development tool, the aim is also to develop easy accessible information and communication for consumers.

Cradle to Cradle$^{(R)}$ Design and Life Cycle Development (LCD)

While LCA can be seen as a static assessment of an inventory, Life Cycle Development (LCD) is rather a dynamic development-tool for new products and systems. And while LCA looks at life cycles from cradle to grave, at least in terms, LCD looks at the planning of products and service systems in a cradle to cradle perspective.
It is based upon the same inventory and impact assessment as in LCA; in fact the EPEA[17] was part of the development of LCA in the 1990s but chose to pursue their own LCD. In each case LCD is developed as an individual company tool, content depending on the specific case and industry. It uses weightings and strategies related to company policies and Cradle to Cradle principles. LCD focuses from the beginning on the parts of the product system and life cycle that need most improvement, and seek solutions for this. Hence the improvements are folded into every stage of the development of the life cycle and value chain as a dynamic process.
Ecological criteria in product design are included from the start. The scope is not limited at the beginning because the focus may shift during the process to reach optimization. The amount of LCA inventory data needed is reduced, as choice of materials is based upon materials that are known to have minimal impacts, and not upon minimizing harmful substances. Examining both quantitative and qualitative levels of material and energy flows, the qualitative ecological impact is the most important. Focus is on how to improve or change the most negative impact of a product life cycle into something better.

Fig. Case wool; Principles for Life Cycle Development

[17] Environmental Protection and Encouragement Agency, Hamburg

There are three nature-based basic principles of Cradle to Cradle Design: *waste equals food*, *use current solar income*, and *celebrate diversity*. These principles are based on the idea that resources must not be lost after they have been used for products but rather maintain their material value for the next generation of productions after use. It distinguishes between Biological Cycles where materials go back into natural cycles, and Technical Cycles where materials are recycled in industry.

Fig. Technical material Cycle and biological material cycle (ill. 2025design)

To handle valuable used materials in a global logistic setting is a big challenge. EPEA has created a model for "Materials Pooling", a business-to-business approach with the aim to create the material logistics needed for collecting, recycling and trading used materials. Partners would share access to a common supply of a particular material, and information to generate a system of closed loop material flows. This still remain a main challenge, since the gap is wide between theory and practice.

Stumbling Blocks

The main stumbling-block for Cradle to Cradle and other initiatives for recycling of used clothing and textiles is the fact that there is no uniform collection system. Even if a given company knows how and is willing to take their garments back, the logistics for doing so represent quite a challenge. It is not a good solution to ship used clothing around the world in order to return the apparel to the producer. Today the labelling of textiles is insufficient, so for example clothing that has been treated with flame-retardant chemicals and heavy-metal dye-stuffs are hardly ever labelled correctly as no country's law requires this in fiber-labelling. Textiles carry a lot of invisible harmful footprints that are never declared on clothing labels. If consumers knew what chemicals are used to make dyes they would be really scared. The Cradle to Cradle development of Climatex Lifecycle[18] (interior fabric in wool and ramie) showcased that out of 1600 chemicals used to dye wool only 16 were accepted as compatible with health and nature. None of the 1600 chemicals were ever visible to the consumer. The focus should be to stop using toxic chemicals, and to make user declarations and labelling telling the consumer what is actually in the material.

Another example is spandex, which may give a wool apparel-item a much longer life, but wrecks havoc in a recycling-process, since the Spandex itself will melt. How to deal with these issues will have to be part of future design-tools and certainly assessments – hopefully clearly communicated to the consumers, since they will be instrumental in the care and end-of-life and recycling-phases.

Another stumbling-block is of course the consumer. Researchers, designers and those who have developed the different tools can claim that cotton is washed more often and at higher temperatures

[18] Climatex Lifecycle, former Rohner Switzerland, now Gessner, the first Cradle to Cradle textile developed

than for example wool (or not, if it serves their purposes), and to a certain degree this is backed by recent findings from the Norwegian National Institute for Consumer Research (SIFO), but what consumers actually do is indeed a big unknown – especially if one looks at the world as a whole. While Italians tend to wash even cotton t-shirts in cold water, other nationalities will set the dial to 60 degrees. And even though wool in theory can be aired and brushed in a routine cleaning-strategy, no-one sits in the world's billions of homes and monitors this behaviour. Lax habits in house-holds on judging what is actually soiled and needs cleaning, and how one actually cleans clothing (hand-wash, machine-wash, tumble-drying, ironing, dry-cleaning) is unchartered land; as is the whole issue of disposal, quality-issues such as pilling, repair, abrasion, etc. As mentioned SIFO is conducting research and some of this will be presented in another paper at the conference, but this is site-specific.

Just as designers using LCA and other tools to improve their eco-footprint are human, and need to interpret the findings and evaluations, consumers are even more apt to make rash decisions. So for wool to become one of the most eco-friendly fibers, both those designing, dyeing, processing <u>and</u> the consumer will have to find an effective way of communicating with each other along the value-chain.