MADE-BY ®

MADE-BY ENVIRONMENTAL BENCHMARK FOR FIBERS – condensed version

Report by MADE-BY, July 2009

Research performed by Brown & Wilmanns Environmental, LLC

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Publishing agreement

This is the condensed version of the total benchmark performed by Brown & Wilmanns. An extended version is only accessible for members within the MADE-BY network.

The following agreement has been made with Brown and Wilmanns regarding communicating about the outcome of the MADE-BY environmental benchmark for fibers:

MADE-BY is allowed to share the extended document solely for the use of its members as a guide for internal design and product development within each member company. Neither MADE-BY nor any member of MADE-BY may publicly disclose the report in whole or in part via print, electronic or other form of publishing without the prior consent of Brown and Wilmanns Environmental, LLC.

This means that MADE-BY member brands are allowed to use the extended document for internal purposes but not share this with anybody outside the MADE-BY network.

However, MADE-BY has agreed with Brown and Wilmanns that the impact parameters, the overall score and some basic explanation can be communicated to external parties. This resulted in the condensed version of the MADE-BY environmental benchmark for fibers which can be also downloaded from the MADE-BY website.

Summary MADE-BY environmental benchmark for fibers

1. Goal of the MADE-BY environmental benchmark for fibers

MADE-BY started its concept almost 5 years ago by motivating brands to replace step-by-step the usage of conventional cotton into organic and/or in-conversion cotton. Additionally, it is MADE-BY's goal to support the affiliated brands to improve the total sustainability of their collections, meaning also advising brands which other sustainable fibers they can use besides organic and/ or in-conversion cotton.

This benchmark focuses on the environmental sustainability and compares the most commonly used fibers in the garment manufacture industry up to fiber ready to spin to yarn level. It acts as a handy guide for designers and production managers on deciding on sustainable alternatives of materials currently used as well as providing a means to create transparency on progress made in this area.

2. Scope of the MADE-BY environmental benchmark for fibers

The benchmark looks at the production process of natural fibers and man-made fibers and the processing involved to produce a fiber ready to spin into yarn. In these 2 first phases of the production process, big differences regarding human and environmental impact can occur on each of the above mentioned parameters. After preparing the fibers in order to be ready for the spinning process, most types of yarn can be treated in a similar way and therefore the spinning, textile processing, distribution, use and maintenance or disposal stages were not included in this benchmark. The one stage that can be fiber type specific is the dye and finishing of textiles. MADE-BY is creating a separate benchmark for this part of the production process, called 'MADE-BY wet processing' benchmark.

3. Development of the MADE-BY environmental benchmark for fibers

Last year MADE-BY came in contact with research company Brown and Wilmanns Environmental, LCC. They specialize in conducting cutting-edge environmental and social responsibility performance researches. It has been agreed that Brown and Wilmanns would develop an 'environmental benchmark for fibers' especially for MADE-BY in which 20 fibers used in the garment manufacture industry are benchmarked.

In order to create this benchmark, Brown and Wilmanns worked very closely together with MADE-BY. Based upon MADE-BY's request, B&W developed a set of 6 parameters which are explained in table 1. Additionally MADE-BY assigned weights to each of the parameters. Following that, B&W collected public data when available for each fiber appropriate to each of the parameters form the origin of the raw materials, through applicable fiber production processes up to fiber ready to spin. As a next step, B&W developed criteria thresholds for each of the parameters and assigned scores to each fiber for each parameter. As a final step they calculated the overall weighted score per fiber ready to spin.
The overall weighted score per fiber ready to spin is translated into the overall ranking (see table 3) and used to create the MADE-BY fiber scorecards for each affiliated brand.

MADE-BY and Brown & Wilmanns will work together to update this benchmark on an annual basis in order to keep up to date with the latest developments and technologies in the market with regard to (sustainable) fibers.

4. Explanation of parameters selected

Table 1: Impact parameters

The first 3 parameters have been given a weight of 20% due to the global scope of the parameters and the ability to measure directly their impact. The remaining parameters are given a weight of 13.33% because their impact can't be measured directly (often subjective factors underlying the production method influence the impact made).

Parameter	Description	Units of measure	Weight
Green house gases (GHG)	Carbon dioxide equivalents (incl fossil emissions without subtracting embedded carbon in product sequestration[1])	Kg CO2 eq/ kg fiber	20%
Human toxicity	• Acute toxicity • Chronic toxicity • Reproductive hazard • Carcinogenicity	LD/LC for oral, dermal, inhalation and skin irritation level Chronic toxicity score and skin sensitization level The State of California Proposition 65 list for developmental hazard IARC Group	20%
Eco-toxicity	○ Acute aquatic toxicity to fish ○ Eco-toxicity potential	LC50 96 hrs Based on Material Safety Data Sheet (MSDS) information	20%
Energy input	Total energy use including feedstock	MJ/ kg fiber	13.33%
Water input	Water input	Kg water / kg fiber	13,33%
Land use	Yield	Kg fiber / ha	13,33%

[1] Sequestration refers to the process by which carbon is removed from the atmosphere via photosynthesis and stored by plants/trees. Plant-based materials (cotton, hemp, PLA, rayon) contain stored carbon from photosynthesis during the plant/tree growth cycle. Additional carbon is stored in root structures and other organic material left in the soil after harvest. The carbon that is left in the soil and which is carried forward with the plant material to the textile is the embedded carbon. The textile product "sequesters" the embedded carbon for a period of time until the textile decomposes or is incinerated/burned, at which point the carbon is released. Similarly, carbon that is sequestered in soil is released once the organic material fully decomposes/composts.
Calculating the amount of carbon dioxide equivalents that are sequestered in a plant-based material is complex. There isn't universal agreement on how that should be done and what factors should be taken into account. Because of the complexity of the issue, we have chosen to not calculate sequestration values and do not do any subtraction from energy-related GHG emissions.

5. Data collection and main underlying assumptions

- The parameters were evaluated using available public data that was collected and analyzed from diverse sources and more than 150 references.

- When possible, 'world average' data have been used. However, the rankings should be considered approximate: some data are regionally specific and would not necessarily be applicable if a fiber was sourced from another region or supply chain using different techniques (e.g rain fed land versus irrigated land).

- The aggregated score of each fiber was based on its most toxic chemical input across the life cycle evaluated in the analysis (hazard based approach). This means that the score given any given fiber in either its human or eco toxicity is based on the worst case compound used in the production or manufacture of that fiber per topic addressed (acute toxicity, chronic, skin sensitizer, carcinogenicity, etc.)[2] There was no adjustment based on exposure or likely dose incurred by a worker. Also, in this hazard based approach, no difference has been made between controlled versus non-controlled processing of fibers, mainly because it is hard to determine which factories / fields have a well-managed / controlled process and which ones have not (some might say that EU factories are better controlled then factories in Asia for example). To an extent this methodology scores synthetic fibers lower as in most situations exposure to chemicals is mediated by engineering controls.

- Energy usage (and therefore GHG emissions) could widely vary based on the specific farm / production facility operations (e.g. if using renewable energy such as wind or solar).

- It is assumed that synthetic fibers had a minimal impact on land use.

- It is assumed that bio-origin chemicals are used in organic farming.

- It is assumed that chemicals were not used in recycled synthetics fibers, although it is likely that detergent and other compounds are used to clean collected and recycled polymer prior to melt spinning. However, no specific information on practices was found. Extra note: there are 2 methods of recycling polyester: mechanical and chemical. In this benchmark the scope was limited to mechanically recycled fibers.

- No energy input has been taken into account for transportation of (recycled) fibers / (recycled) synthetics to yarn spinning mills. The main reason for this is that there isn't sufficient world average data available (since yarn suppliers use often multiple producers of fibers / synthetics located in different places, depending on the order requirements). Note: additionally it is worth mentioning that especially the infrastructure required to return recyclable materials to collectors and finally to facilities manufacturing the recycled fibers is not yet well developed.

[2] For example, there are 10 compounds used to manufacture a fiber and 4 of those 10 compounds are carcinogenic. Of these four, three are IARC 2B carcinogens (possible human carcinogen) but one is an IARC group 1 (known human carcinogen) we used the worst scoring carcinogen to assign the toxicology score. The poorest performing attribute was used to calculate the human and eco toxicology per aspect that we considered.

- Missing data was filled out using available ratios (f.e. some numbers for recycled fiber were calculated as a percentage of virgin fiber data).

- When no alternative existed, Brown and Wilmanns created an estimate based on their expert judgment extrapolated from their experiences with similar situations.

> Important to note is that MADE-BY sees the limitations of analyzing and ranking the different types of fibers ready to be spin into yarn into one environmental benchmark for fibers. However, we accept this limitation since, in order to move forward in using more sustainable fibers, one needs to use a classification system and measure progress.

6. Calculating the outcome

Each parameter was normalized to a common scale and then aggregated so fibers ready to spin into yarns could be compared and ranked. For each parameter thresholds were developed.

The scores for each of the parameters were divided into 3 classes: good, neutral and bad. The classes were determined individually based on the metrics used for the parameters. Finally, the overall weighted score per fiber ready to spin into yarn - type was calculated and assigned to the 5 categories within the MADE-BY environmental benchmark for fibers: Class A – Class E.

MADE-BY added an additional category, called 'Unclassified' in which those fibers are listed that are not (yet) part of this benchmark due to a lack of available data. Over time, MADE-BY aims to incorporate these fibers into one of the 5 defined classes.

Table 2: Overall ranking

Class A	**Class B**	**Class C**	**Class D**	**Class E**	**Unclassified**
Recycled cotton Recycled nylon6 Recycled polyester Organic hemp Organic flax (linen)	Tencel® (Lenzing lyocell product) Organic cotton In conversion cotton	Conventional hemp Ramie PLA Conventional flax (linen)	Virgin polyester Poly-acrylic Lenzing Modal® (viscose product)	Conventional cotton Virgin nylon6 Rayon cuprammonium Bamboo viscose Wool Generic viscose	Silk Organic wool Leather Elasthan (Spandex) Acetate Cashmere wool Alpaca wool Mohair wool Fiber-base bamboo etc

Interesting to state is that the garment production industry is currently being dominated by cotton (+/- 35% of the global fiber market) and polyester (40% of the global fiber market). Both are classified in the 'lower' categories (class E respectively D). Luckily the industry is offering now good sustainable alternatives that become more and more available on a larger scale: conventional cotton can be substituted by organic / in conversion cotton and virgin polyester by recycled polyester.

7. Explaining the outcome

General justification notes:

➢ Energy input:

- All recycled fibers and fibers made from natural sources score ‘good’ on the energy input parameter since relatively little energy is needed to produce the fibers and prepare them for the spinning process. An exception should be made for wool (score is neutral) since a few MJ of additional energy required in the fiber production fell outside the statistical cutoff to rate a ‘good’.

- Overall, all man-made fibers (both synthetic and natural based polymers) score ‘bad’ on energy input since a high amount of MJ’s is needed to convert these types of resources into fiber which is ready to spin into yarn.

➢ GHG:

- All recycled fibers score ‘good’ on the GHG parameter because, in many cases, manufacturing products from recycled materials is less energy intensive and associated with fewer GHG emissions than making products from virgin materials.

- All man-made fibers score ‘bad’ on the GHG parameter because a high amount of GHG are produced when manufacturing the plant based feed-stocks (natural polymers) and / or fuels (synthetic polymers) into fibers that are ready to spin into yarns. An exception should be made for Tencel and Modal production since these production processes have lower energy usage and they try to reclaim some of the biomass used in the process.

➢ Water input:

- All fiber types (natural and man-made) score good on water input with the exception of cotton and viscose related fiber types. The cultivation of cotton, regardless of being organic or not, can require a relatively high amount of water to produce, while viscose fiber types especially require a lot of water during the manufacturing process.

➢ Land use:

- All recycled fibers and man-made fibers score ‘good’ on the land use parameter since very little land is needed to produce the recycled fibers or man-made synthetic fibers. For the man-made cellulose based fibers (like viscose) land is needed though, but the yield of fiber per ha of land is very good (especially fibers like bamboo have a high growth rate and can grow in diverse climates). The yields for bast fibers can vary widely according to geographical location and cultivation techniques.

➢ Eco- and Human toxicity:

- All recycled fibers and organic fibers score good on both the eco- and human toxicity parameters since it is assumed that no (or a limited amount of) chemicals were used for the recycled fibers and the organic allowed chemicals chosen for the organic scenarios where relatively non-toxic.

Future developments

- Review and update this benchmark on an annual basis, based on new information available. It is expected that over time the fibers in the unclassified category can be categorized in one of the A-E categories.

- Incorporate the rating of silk as soon as this information becomes available (the use of company confidential information regarding silk is still awaiting final approval).

- Set up and manage a list of most desired fiber types to be included in the benchmark, like organic wool and 'generic' lyocell fibers.