SUSTAINABLE FIBRE TOOLKIT

SST
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SUSTAINABLE FIBRE TOOLKIT

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PREFACE

From finding innovative ways to use natural resources to having a positive influence on communities around the world, designing for a positive environmental and social influence can be a compass by which you run your business. Designing for sustainability can provide an infinite and rich framework for creativity, innovation and increased profit.

YOUR COMPANY HAS A UNIQUE OPPORTUNITY TO DEFINE WHAT DESIGN FOR SUSTAINABILITY MEANS TO YOU AND YOUR CUSTOMERS.

This Sustainable Fibre Toolkit provides an overview of the environmental impacts of fibres at each stage of the lifecycle, and offers suggestions on how to design around or reduce them. The Toolkit is intended to aid and inspire manufacturers, buyers, merchandisers, designers and producers in lowering the ecological and social impact of their company, and in turn thriving from the effects it brings to individuals and the company.

The recommendations are not prescribed, but build upon external standards (like organic, for example) that currently exist. The emphasis is on innovation, creativity and opening up new ways to optimize the use of increasingly scarce natural resources.

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CONSIDERATIONS

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CHALLENGES & OPPORTUNITIES

There is no single solution to sustainable fibre selection. Each fibre has different impacts at different points in its lifecycle, and appropriate (and actionable) responses are complex. Lack of transparency around manufacturing practices, traceability, a fragmented industry, lack of agreement on the means to measure and assess lifecycle data, cost and more—all influence the decisions for sustainability we are able to make on a daily basis. Trade-offs are inevitable.

BUT THESE CHALLENGES CAN ALSO BE EXCITING,
FOR THEY INEVITABLY LEAD TO INNOVATION.

In order to innovate around sustainability, understanding the impacts of each fibre that your company currently uses is essential. And knowing the options and processes currently available can lead to rapid adoption of alternatives,
with multiple benefits.

We'd like to invite you to play an active role in the continued development of this Toolkit. Feel free to contact us with additional thoughts and recommendations as you ask questions of suppliers and manufacturers and test your own ideas in the field.

NATURAL FIBRES

Natural fibres are divided into two main classifications: animal (protein) fibres and plant (cellulose) fibres.

Protein fibres are derived from animals and include wool, cashmere, alpaca, silk and leather.

Cellulose fibres are derived from plants, and are products of agriculture. Fibres are either bast fibres (the fibre found in the stem of the plant) such as flax or hemp, or seed fibres such as cotton.

Each of the fibres included in this chapter inherently possesses natural sustainability attributes.

THE GOAL IS TO ACCENTUATE AND ENCOURAGE NATURAL ATTRIBUTES AT EVERY STAGE OF FIBRE AND FABRIC PROCESSING, AND THROUGHOUT THE RESULTING PRODUCT'S LIFECYCLE.

ALPACA

The textile fibre obtained from alpaca is simply called “alpaca fibre.” Alpaca fibre has inherent sustainability attributes: It is a renewable, natural fibre that can be used as a viable alternative to cashmere, wool from sheep and even synthetic fabrics.

NATURAL FIBRE

BENEFITS

There are two different breeds of alpacas: huacaya and suri. The main physical difference between these two alpacas is the fleece. Like wool from sheep, fibre from huacaya has a natural crimp and when the fleece grows out they look fluffy. Suri fibre has no crimp in its fleece, and the fibre drapes down from its body. It is soft and silky, and can be used as an alternative to silk.[1]

Alpacas have padded feet and toenails rather than hooves. Because of this, they are very gentle on the pasture. Alpacas don't consume the root of grass like sheep and Kashmir goats, so the grass can continue growing after they have eaten it.[1]

Alpaca fibre is a natural fibre and renewable. It is valued for its natural warmth and water repellence.

Alpaca fibre is highly valued for its softness, durability and silkiness. Due to its low micron count (20-70), it is very comfortable to wear and is also lightweight. It is naturally non-pilling.

The surface of alpaca fibre is water-, dirt- and stain repellent, whilst the fibre interior is highly moisture absorbent. Alpaca fibre is dyed readily and is naturally fire resistant. Since there is no need for the use of fire retardant coatings or synthetic topical finishes on wool, it may be used as a viable alternative to synthetic fabrics.[2]

Alpaca fibre absorbs odours and is, to some extent, self-cleaning. It tends not to smell bad, even after long periods of wear. Because of this, alpaca fibre garments and products do not need to be washed frequently.[3]

Alpaca fibre comes in 22 natural colours, including white, browns, greys and black, potentially eliminating the need to use synthetic dyes.[1]

SURI ALPACA FIBRE CAN BE USED AS AN ALTERNATIVE TO SILK.

Alpaca fibre does not contain lanolin or grease, so it can be easily cleaned in a rinse bath with natural products.[4]

In 100% form, alpaca fibre fabric is **biodegradable** after its useful life, though absolute biodegradability depends on the dyes and trims used, and route of disposal.

MORE INFO APPENDIX: BIODEGRADABILITY

POTENTIAL IMPACTS

DYEING

The dyeing process for alpaca fibre involves standard industry chemicals and water use. Certain types of dyes are suspected carcinogens and mutagens, and untreated dye water can negatively impact receiving water bodies and harm aquatic ecosystems if left untreated before its release.

MORE INFO PART 5: DYEING & PRINTING

CONSUMER CARE/WASHING

Alpaca fibre fabrics may be handwashed, spot cleaned, or dry-cleaned, depending on the product. Washing and caring for any product can cause significant environmental impacts due to chemicals used in cleaning products.

MORE INFO APPENDIX: CONSUMER CARE & WASHING

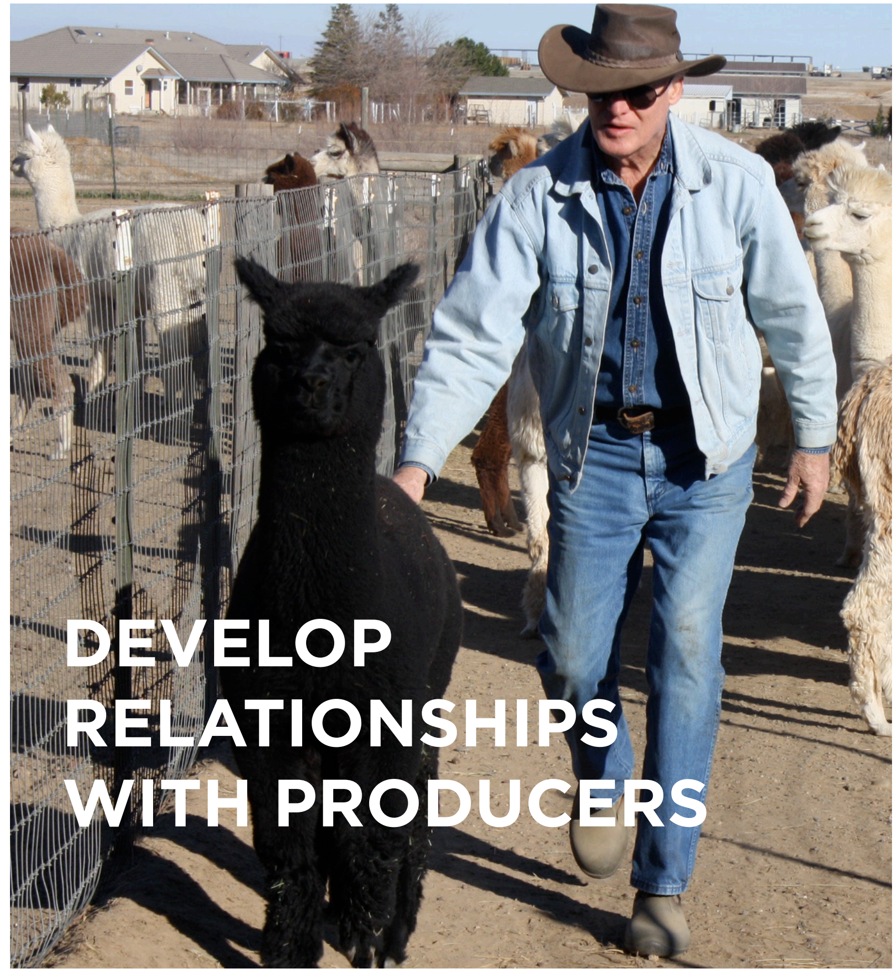
END OF USE

Although 100% alpaca fibre is **biodegradable**, the amount of time it could take for a alpaca product to decompose naturally and in a short period of time is dependent upon a number of conditions—including how much air, temperature and sunlight the fibre is exposed to. If the waste is buried in a landfill, it can take even longer for it to break down.

MORE INFO APPENDIX: BIODEGRADABILITY

OPTIMIZE SUSTAINABILITY BENEFITS

- Promote the use of alpaca fibre as an alternative to wool, cashmere, silk and synthetics.
- Develop relationships with producers and monitor farmers to ensure animal-friendly practices are being implemented.
- Promote the use of natural colour alpaca fibre.
- Promote **OEKO-TEK® certified** alpaca fibre.[6]



MONITOR FARMERS TO ENSURE ANIMAL-FRIENDLY PRACTICES ARE BEING IMPLEMENTED.

Bruce Nelson on his alpaca farm, California, USA.

AVAILABILITY

Alpaca fibre is available from producers in Peru, North America and Australia.

APPLICATIONS

Knitwear applications in clothing, accessories, outerwear, baby clothing, blankets, rugs, upholstery.

MARKETING OPPORTUNITIES

renewable resource

OEKO-TEK® Standard 100 certified If verified and used.

biodegradable All fibres, yarns, trims and dyes used to manufacture the product or garment must also be biodegradable, or disassembled before disposal. This should be substantiated with documentation that the product can completely break down into non-toxic material by being processed in a facility where compost is accepted. Secondary label or marketing material should be provided to instruct customer.

MORE INFO APPENDIX: BIODEGRADABILITY

natural colour If no dyes are used.

INNOVATION OPPORTUNITIES

1. To minimize cost, use alpaca in blends with organic wool or cotton.

2. Use naturally coloured alpaca fibre to create heathers with white wool or cotton.

3. Design garments that use alpaca fibre in strategic areas, such as under the arms, to emphasize its self-cleaning and moisture absorbent attributes.

4. Create an alpaca product that is 100% biodegradable and compostable: the product can break down in a reasonable amount of time and can provide valuable nutrients to the soil after disposal.

5. Know whom your fibre or product is being sourced from. Be aware that when there is high demand for a fibre—a fibre that typically gets produced in poor countries with little or unenforced regulations for workers and animals—the likelihood of animal cruelty and poor worker conditions increases.

1. Nelson, Bruce. Personal interview. 5 Jan. 2014.
2. www.wildhairalpacas.com/pages/1414/wild-hair-alpacas-llc-whats-so-special-about-alpaca-fibre
3. Sheep and Wool, Animal industry, http://www.h-ed.com.au/think/13-animal-industry/43-sheep-and-wool.html?
4. www.usalpacacompany.com/Alpaca-Fibre.html
5. www.greenlivingtips.com/articles/waste-decomposition-rates.html
6. www.OEKO-TEK.com/media/downloads/Factsheet_OETS_100_EN.pdf

BAMBOO LINEN

Bamboo linen is a natural fibre, and processing into yarn is largely mechanical with minimal environmental impact. Bamboo linen can be used as a sustainability choice that accentuates the many attributes of the bamboo plant.

NATURAL FIBRE

BENEFITS

Bamboo is a “rapidly renewable” resource, meaning that it grows quickly and can be harvested at least once a year.[1]

FAST-GROWING RENEWABLE FIBRES

FIBRE	LENGTH	TIMING
Bamboo	24 meters	40 days[1]
Hemp	4 meters	3 months[5]
Jute	1-4 meters	3-4 months[4]
Flax	1 meter[2]	3-4 months[3]

Bamboo linen has a natural ability to breathe and wick moisture away due to its porous nature. It keeps the wearer cooler—by one to two degrees—than someone wearing cotton.

Bamboo is a biologically efficient, low maintenance crop that requires few chemical inputs during the growing season. It is mainly rain fed, and can grow in diverse climates.

Due to its speedy growth and little input needed for growing, some say that using bamboo as an alternative to wood trees could help slow deforestation.[1]

Once the fibre is extracted from the stem, processing bamboo into yarn for linen is largely mechanical, with minimal environmental impact.

In 100% form, linen from bamboo fabric is **biodegradable** after its useful life, though absolute biodegradability depends on the dyes and trims used, and route of disposal.

SOME SAY THAT USING BAMBOO AS AN ALTERNATIVE TO WOOD TREES COULD HELP SLOW DEFORESTATION.[1]

POTENTIAL IMPACTS

PROCESSING

When processing for linen, bamboo is a bast fibre and is extracted directly from the stalk of the plant in a process similar to that used for jute, hemp and flax. The fibre is extracted through a process called **retting**, which separates the fibre from the stems using microorganisms and moisture. This is carried out in the field (as with dew retting) or in tanks (water or chemical retting). Dew retting is preferred as it utilizes the natural moisture of dew, but is the longest process, taking over 2–3 weeks to break down the stems slowly. Although chemical retting is the fastest process, the waste-water is concentrated and rich in chemicals and biological matter, which negatively impacts receiving water bodies, harming aquatic ecosystems, if left untreated before its release.[6]

DYEING

The natural colour of bamboo fibre is golden, and bamboo for linen must be bleached with chlorine to render it light enough to receive dyes for light or clear shades. Chlorine bleach can form halogenated organic compounds in the wastewater. These compounds **bioaccumulate** in the food chain, are known **teratogens** and **mutagens**, are suspected human **carcinogens** and cause reproductive harm.

MORE INFO PART 5: DYEING & PRINTING

END OF USE

Although 100% linen from bamboo fabric is claimed to be biodegradable, the amount of time it could take for a product to decompose naturally and in a short period of time is dependent upon a number of conditions—including how much air, temperature and sunlight the fibre is exposed to. If the waste is buried in a landfill, it can take even longer for it to break down.[7]

MORE INFO APPENDIX: BIODEGRADABILITY

RETTING PROCESS COMPARISION CHART[6]

TYPE	DESCRIPTION	ADVANTAGE	IMPACTS	DURATION
Dew Retting	Plant stems are cut or pulled out and left in the field to rot.	Returns nutrients back into the soil.	Reduced fibre strength; low and inconsistent quality; influenced by weather; and product is contaminated with soil.	2–3 weeks
Water Retting	Plant stems are immersed in water (rivers, ponds or tanks) and monitored frequently.	Produces fibre of greater uniformity and higher quality.	Extensive stench and pollution arising from anaerobic bacterial fermentation of the plant; high cost; low-grade fibre. Requires water treatment maintenance.	7–14 days
Chemical Retting	Boiling and applying chemicals, normally sodium hydroxide, sodium benzoate, hydrogen peroxide.	More efficient and can produce clean and consistent long and smooth surface bast fibre within a short period of time.	Unfavorable colour; high processing cost. The wastewater is concentrated and rich in chemicals and biological matter, which negatively impacts receiving water bodies, harming aquatic ecosystems, if left untreated before its release.	60–75 minutes

OPTIMIZE SUSTAINABILITY BENEFITS

OPPORTUNITY	BENEFITS	CONSIDERATIONS
Know the difference between natural bamboo linen fabric, and bamboo made from a viscose process.		Bamboo viscose is chemically processed and has greater pollution impacts to water and air. MORE INFO PART 3: MANUFACTURED FIBRES
Promote the use of linen from bamboo products.	Once the fibre is extracted from the stem, processing bamboo into yarn for linen is largely mechanical, with minimal environmental impact.	
Promote suppliers using organic bamboo.	Ensures that no disallowed fertilizers are used.	Organic certification must be in place by a recognized international certification agency accredited by **IFOAM**. Organic linen from bamboo is not as readily available as conventional linen from flax.
Promote the use of natural colour.	No bleaches or dyes are used in this case, and associated pollution impacts are avoided.	
Promote the use of non-chlorine bleaches, such as hydrogen peroxide, to lighten the natural beige colour for dyeing dark shades and bright/light shades.	Hydrogen peroxide harmlessly decomposes into water and oxygen gas.	Non-chlorine bleaches do not strip out the original colour of the fibre. Consequently, lighter and brighter colours will be duller due to the over-dyed effect. Non-chlorine bleaching is adequate for dark colours, which mask the original beige tone.
Promote the use of ozone bleaching processes to strip out the natural beige colour of linen (from flax). **Promote the particular aesthetic of ozone bleach effects.**	Ozone can used be with no water at all.	Ozone has limited availability, and is relatively expensive since it requires investment in ozone generating equipment. Ozone processes produce a different aesthetic than chlorine derivative or permanganate bleaching.
Promote suppliers who use dew retting over water or chemical retting.	Dew retting reduces the biological load in the receiving water bodies, and adds nutrients to the soil.	The natural colour may vary slightly from lot to lot, since the process is influenced by weather.
Promote the use of enzymes to strip out the natural beige colour of bamboo linen.		Enzymes are not allowed in **GOTS** standards. Enzymes produce a different aesthetic than chlorine derivative or permanganate bleaching.

AVAILABILITY

Bamboo linen fabric is available from Deltracon in Belgium. This company produces a heavier quality bamboo linen fabric suitable for home furnishings.

Expressing an interest in bamboo linen fabric to your suppliers can help to expand its availability worldwide.

APPLICATIONS

Linen from bamboo fabrics are seen in both knits and wovens, and range from medium-weight jerseys to heavyweight wovens for trousers.

PROMOTE THE USE OF BAMBOO LINEN PRODUCTS.

Armani Collezioni 100% bamboo linen shirt.

MARKETING OPPORTUNITIES

bamboo linen Fabric should not be referred to simply as "bamboo," since the processing of bamboo into linen and into rayon varies significantly. The bamboo textile should be referred to more specifically as "bamboo linen" or "viscose made from bamboo." This should be done consistently on labeling, hangtags and POS.[8]

organic (if organic bamboo fibre is used) All fibres, yarn, trims and dyes used to manufacture the garment must comply with the **GOTS** organic garment standard. Simply state "made from 100% organic bamboo," if this is verified and accurate.

biodegradable All fibres, yarns, trims and dyes used to manufacture the product or garment must also be biodegradable, or disassembled before disposal. This should be substantiated with documentation that the product can completely break down into non-toxic material by being processed in a facility where compost is accepted. Secondary label or marketing material should be provided to instruct customer.

non-chlorine bleached If alternative bleach is used.

dew retted If dew retted processed.

enzyme retted If enzyme retted processed.

fast-growing natural resource.

low water footprint in cultivation.

INNOVATION OPPORTUNITIES

1. Use linen from bamboo fibre in blends with cotton to achieve grey/beige heather effects, then over-dye the cotton side to achieve heathered colours without using chlorine bleach.

2. Use 100% bamboo linen in stripes with cotton, then over dye to achieve tonal colours without using chlorine bleach.

3. Since bamboo linen wrinkles easily, and washing and caring for the garment can cause significant environmental impacts, design garments that utilize the natural wrinkling of the fabric as a design feature to influence the customer to reduce ironing of the final product and the energy it uses.

4. Create a bamboo linen product that is 100% **biodegradable** and **compostable**: the product can break down in a reasonable amount of time and can provide valuable nutrients to the soil after disposal.

5. Encourage handwashing or spot cleaning on the hangtag and labeling/POS to influence the consumer to take an active role in reducing environmental impacts.

1. voanews.com/content/a-13-2006-08-29-voa51/323110.html
2. www.hempage.de/cms/
3. decktowel.com/pages/how-linen-is-made-from-flax-to-fabric
4. swicofil.com/products/003flax.html
5. fao.org/economic/futurefibres/fibres/jute/en/
6. www.ncsu.edu/bioresources/BioRes_06/BioRes_06_4_5260_Paridah_ASZ_Retting_Bast_Fibre_Quality_Review_1312.pdf
7. www.greenlivingtips.com/articles/waste-decomposition-rates.html
8. business.ftc.gov/documents/alt172-how-avoid-bamboozling-your-customers

Other:
www.nrdc.org/international/cleanbydesign/files/CBD_FibreFacts_Bamboo.pdf

COTTON

The high global demand for cheap cotton fibre encourages large-scale intensive production with significant ecological and social impacts.

Finding alternatives that mitigate the ecological impacts of cotton will not only reduce the company's environmental impacts, but may also influence the textile industry as a whole.

NATURAL FIBRE

Cotton represents 35% of the world's textiles and is the second largest fibre category worldwide.[1] China, India, the United States, and Pakistan account for more than 70% of global cotton production.[2]

BENEFITS

Cotton is a renewable natural resource and is readily available and inexpensive. Cotton fibre is almost pure cellulose, and is soft, breathable, and absorbs moisture readily, making cotton clothes particularly comfortable in hot weather. The fibre's high tensile strength in soap solutions renders cotton garments easy to wash, and no dry-cleaning is required.

In 100% form, cotton fabric is biodegradable after its useful life, though absolute biodegradability depends on the dyes and trims used, and route of disposal.

By-products from cotton include cottonseed oil, cottonseed meal, and cottonseed hulls, which are mainly used to feed livestock, and can also be used for petroleum refining and plastics manufacturing.[3]

POTENTIAL IMPACTS

CULTIVATION: Chemical

Conventional cotton cultivation uses some of the most toxic chemicals (pesticides, defoliants and fertilizers) available for use in agriculture and accounts for 16% of global insecticide applications worldwide; more than any other crop.[4] Many of these chemicals are used by farmers in developing countries where education, access to information and understanding of the dangers posed by hazardous chemicals are lacking. Consequently, cotton farmers may experience acute pesticide poisonings, which can result in illness and death. The use of toxic chemicals can diminish soil fertility over time, and irrigation run-off can pollute regional water bodies.

CULTIVATION: Water

Unlike flax, which is rainfed, cotton generally requires irrigated water during its cultivation. Water management practices vary from growing region to growing region and are influenced by a number of factors including the farming system used, water costs, local climate, etc. Water footprint information for cotton products is available in the public domain, but because different organizations use different parameters for their calculations, water footprint estimates for a particular product vary widely and can be somewhat unreliable. For example, one source claims that it takes 5678 litres of water to produce enough cotton for a pair of jeans, whereas another source reports that it takes 1892 litres.[5, 6]

AS BRANDS IN THE INDUSTRY COLLABORATE ON INFORMATION AND STRATEGIES FOR SUSTAINABILITY, FOOTPRINT TOOLS WILL BECOME MORE NORMALIZED, CONSISTENT AND RELIABLE.

Cotton is mainly grown in Mediterranean desert or near-desert climates, where fresh water is in short supply. Consequently much of the global cotton crop is irrigated and this can have extensive impacts on regional freshwater resources.

CULTIVATION: Labor

In countries where cotton is handpicked, fair treatment of the farm workers may be of concern. In Uzbekistan, for example, one of the largest exporters of cotton in the world, more than one million children, students, teachers and doctors are forced by the national government to work in the country's cotton fields for a two-month period each fall. In recent years, over 130 apparel companies have pledged to boycott Uzbek cotton, but its effectiveness is unclear. According to reports in the Russian press, China and Bangladesh will purchase 83% of this year's harvest.[7]

POTENTIAL IMPACTS

DYEING

The dyeing process for cotton involves standard industry chemicals and water use. Certain types of dyes are suspected carcinogens and mutagens, and untreated dye water can negatively impact receiving water bodies and harm aquatic ecosystems if left untreated before its release.

MORE INFO PART 5: DYEING & PRINTING

CONSUMER CARE/WASHING

Cotton is often washed and tumble-dried at high temperatures and can require pressing. Studies on consumer garment washing habits, looking at a typical women's short sleeve cotton T-shirt in size small, indicate that washing is the single largest contributor to greenhouse gas emissions (constituting 48% of the total value) compared to other lifcycle consideratons such as manufactoring, transportation, packageing, retail and disposal.[8]

MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

Although 100% cotton fibre is biodegradable, the amount of time it could take for a cotton product to decompose naturally and in a short period of time is dependent upon a number of conditions—including how much air, temperature and sunlight the fibre is exposed to. If the waste is buried in a landfill, it can take even longer for it to break down.[9]

MORE INFO APPENDIX: BIODEGRADABILITY

ALTERNATIVES

Alternatives to conventional cotton include genetically modified (GM), certified organic, transitional organic/organic in-conversion and Integrated Pest Management (IPM).

GENETICALLY MODIFIED (GM) COTTON

Due to its high susceptibility to pests and pathogens, and high pesticide consumption, cotton has been a major focus for genetic modification. Cotton is one of the top three genetically modified (GM) crops in the world, along with corn and soy. Although some European countries have banned the use of GM seed entirely, other countries have continued to rely on it.[12] In the United States and India in 2013, sources state that 90% of cotton crops are genetically modified.[13, 14] GM is a relatively new technology and its long-term effects are not yet fully understood. So, the pros and cons of GM technology are still hotly debated. For example, in humid growing regions, such as the U.S. state of Georgia, where boll weevil is rampant, **GM (Bt)** cotton has shown significant pesticide reductions.

On the other hand, **herbicide tolerant (Ht)** GM cotton, otherwise known as "Roundup Ready," has led to a sharp increase in herbicide use, which has in turn caused genetic resistance in weeds. Farmers report having to use more toxic herbicides to suppress "super weeds."

To add to this complex picture, proponents of GM cotton note that herbicide tolerant (Ht) varieties have also led to reduced soil tillage, which results in less topsoil erosion.

GM cotton seed is more expensive than regular cotton seed because seeds cannot be saved and replanted the next season. GM cotton is grown as conventional, and is readily available in large quantities, through normal supply channels and is priced the same as conventional cotton.[15]

CERTIFIED ORGANIC COTTON

Certified organic cotton disallows the use of GM seeds and restricts or disallows the use of many synthetic agricultural chemicals. Organic farming aims to self-stabilize agro-ecosystems and uses crop rotation and biological means to control pests and pathogens.

STUDIES SHOW THAT ORGANIC FARMING:

- BUILDS ORGANIC MATTER IN THE SOIL
- REDUCES SOILAIR AND WATER CONTAMINATION
- INCREASES SOIL FERTILITY AND BIODIVERSITY
- REDUCES HUMAN AND WILDLIFE HEALTH HAZARDS
- REDUCES GREENHOUSE GAS EMISSIONS RESULTING FROM THE PRODUCTION OF SYNTHETIC FERTILIZERS AND PESTICIDES.[16]

In some regions, organic cotton farmers may gain more income, though this is by no means universal. Potentially lower yields, higher labor costs and a market price determined by the commodity price index, mean organic cotton cultivation is a tenuous financial risk for the farmer. Be sure to verify claims about increased income to organic farmers before using in marketing materials.

Organic cotton represents less than 0.7% of global cotton grown worldwide and is therefore in short supply.[17] The price of organic cotton tends to be higher than conventional due to the increased labor costs necessary for its cultivation. Organic fibre also requires special processing since it falls outside the usual scope of the commodity cotton supply chain. For example, track and trace mechanisms must be implemented in developing countries where bar code and bale identification systems are not in place. This requires additional labor and monitoring. Certified organic cotton must also remain segregated through processing into yarn and fabric, and this special handling adds additional costs.

Certification by a third party ensures that all of the proper documentation is in place, and that the organic claims are valid.[16] Exact cultivation requirements vary from region to region, since each bioregion has different pest pressures and resources, but there is international reciprocity between most certification agencies accredited by **International Federation of Agriculture Movements (IFOAM)**.

Organic certification does not necessarily guarantee low water use, fair labor practices or a fair price to the farmer.

GLOBAL ORGANIC COTTON PRODUCTION
TOP 5 COUNTRIES (2011-2012)[18]

COUNTRY	METRIC TONNES	FIBRE PRODUCTION % OF TOTAL
India	103,004	74.20
Turkey	15,802	11.38
China	8,106	5.84
Tanzania	6,891	4.96
United States	1,580	1.14

ALTERNATIVES cont'd

TRANSITIONAL ORGANIC COTTON/ ORGANIC IN-CONVERSION

In order to be certified as organic, cotton fields must go through a 2-year transition period (3 years in the United States) where disallowed chemicals are not used. Transitional organic cotton uses non-GM seed, is grown in the same manner as organic but is still transitioning through this 2-year phase to certification. Once the land on which it is grown has completed the 2-year requirement, the fibre can be labeled as organic.

Transitional cotton creates a bridge for farmers to switch from conventional to organic cultivation and it may be cheaper than organic; since it isn't yet certified it doesn't command the same "value-added" in the market. However, transitional organic cotton is not as readily available as conventional and reciprocity in labeling from nation to nation has yet to be established. Currently, labeling for transitional cotton is only allowed in Europe, where it is called "organic in-conversion" and must be certified under the European organic standard. The U.S. does not allow labeling of transitional. The Organic Exchange in Europe has a transitional cotton task force and is currently lobbying the USDA to allow labeling of transitional cotton in the United States.[19]

INTEGRATED PEST MANAGEMENT (IPM) COTTON

Integrated Pest Management (IPM) is an approach to farming that focuses on long-term prevention of pests by integrating biological controls, habitat manipulations and modification of cultural practices. Pesticides are used only after monitoring and established guidelines indicate that pests exceed acceptable levels.[20]

There are many different IPM cotton initiatives globally, and IPM can be interpreted and implemented in many different ways. However, there are two notable IPM programs emerging that are based on clear and accessible data, interpretations and strategies.

Better Cotton Initiative (BCI)

The Better Cotton Initiative (BCI) was established in 2005 and is active globally, addressing environmental, social and economic issues in an integrated program that reduces water and chemical use. BCI does not allow child or bonded/forced labor; incorporates better treatment of female workers, proper handling and training for the use of pesticides and fertilizers; and encourages a number of techniques that will reduce water use. BCI engages and supports all cotton supply participants, from producers to retailers, and provides a central digital repository of BCI bales with unique bale identification codes. BCI is currently working with farmers in Brazil, India, Mali, Pakistan and China, with active retail members such as H&M, IKEA and Levis Strauss.[21, 22]

Sustainable Cotton Project's Cleaner Cotton™ Field Program[20]

Cleaner Cotton™ uses non-GM seed and is grown using biological means to control pests. The Sustainable Cotton Project (SCP) provides technical support to growers to implement Integrated Pest Management (IPM) practices on their cotton crop. SCP field scouts conduct weekly monitoring on fields registered in the Cleaner Cotton program and provide growers with a written report on the condition of the crop, observations about pest and beneficial insect populations, beneficial insect habitats and any areas of concern. Cleaner Cotton disallows the 13 most toxic chemicals used in cotton, and requires growers to use biological means as a first resort if an infestation occurs. If pests threaten to cause significant economic losses and all biological options have been exhausted, the growers are allowed to use sprays, but never the disallowed chemicals. Because Cleaner Cotton is non-GM it may be a stepping-stone to organic.[20]

Cleaner Cotton™ is grown and ginned in California, and each bale is labeled with the Cleaner Cotton trademark. All U.S. cotton bales, including those that are Cleaner Cotton, are tracked by the USDA PBI (permanent bale identification system), which traces each bale back to the farmer and field where it was grown. Cleaner Cotton can be shipped anywhere in the world for spinning and processing into fabrics and garments. In fact, 95% of California's cotton harvest, including Cleaner Cotton, is shipped overseas.

OTHER COTTON CATEGORIES

OEKO-TEK CERTIFIED COTTON[24]

OEKO-TEK is an independent, third party certifier that offers two certifications for textiles: OEKO-TEK 100 (for products) and OEKO-TEK 1000 (for production sites/factories). OEKO-TEK 100 label aims to ensure that products pose no risk to health. These products do not contain allergenic dye-stuffs and dye-stuffs that form carcinogenic aryl-amines, and several other banned chemicals. The certification process includes thorough testing for a long list of chemicals.

OE BLENDED STANDARD[25]

The OE Blended Standard is a standard for tracking and documenting the purchase, handling and use of certified organically farmed cotton fibre in blended yarns, fabrics and finished goods. The standard applies to all goods containing a minimum of 5% organic cotton, and helps consumers and companies to confirm the correct percentage of organic cotton in their product.

OE 100 STANDARD[26]

The OE 100 Standard is a standard for tracking and documenting the purchase, handling and use of 100% certified organic cotton fibre in yarns, fabrics and finished goods. The OE 100 Standard helps consumers and companies to confirm the correct percentage of organic cotton in their product.

OTHER COTTON CATEGORIES cont'd

NATURAL COLOURED COTTON

Coloured cotton is a naturally pigmented fibre that grows in a variety of colours, including purples, mauve and, more commonly, brown and green shades, and may be cultivated organically or conventionally. Coloured cotton reduces the overall volume of dyes (and associated pollution), since it can be used undyed. Coloured cotton is in short supply and is much more expensive than white organic fibre. In addition, coloured cotton fibres are significantly shorter than white cotton and this can cause quality problems when used in 100% and finer count yarns; yarns may snap on power spinning frames, weaving equipment and when sewing knit fabrics. However, blending coloured cotton with longer staple white cotton and/ or developing 2- to 3-ply yarns can counter this potential quality problem. The brown and green shades of coloured cotton tend to darken with washing and fade with exposure to light. Extensive testing should be conducted to ensure yarns and fabrics meet acceptable commercial quality.

FAIRTRADE COTTON

The Fairtrade program is active globally, primarily in developing nations, and secures a minimum fibre price for the farmer aiming to cover the average costs of sustainable production. In addition to this baseline price for their fibre, farmers also receive a Fairtrade premium, which allows them to invest in community projects, such as schools, roads or health care facilities. Most Fairtrade cotton is neither organic nor IPM. However Fairtrade standards encourage sustainable farming practices by restricting the use of certain agrochemicals. Fairtrade minimum prices for organic cotton are generally set 20% higher than the Fairtrade conventional minimum prices.[23]

KNIT CARDIGAN MADE FROM ORGANIC, NATURAL COLOURED COTTON.

honest by Muriée

Image source: www.honestby.com

OPTIMIZE SUSTAINABILITY BENEFITS

DESIGN OPPORTUNITY	PRODUCTION OPPORTUNITY	MARKETING OPPORTUNITY	CONSIDERATIONS
Promote the use of organic cotton.	**Work with design and marketing to forecast styles and volumes and contract organic fibre in advance to ensure supply.**	• Consumers are familiar with the term "organic."	• Higher price. Less availability. • Design high value items in organic, which can absorb higher fibre costs. • Design organic into items that are highly processed, so the fibre cost is a smaller percentage of the total garment cost.
Promote the use of biological IPM cotton.	**Work with design and marketing to forecast styles and volumes and contract IPM fibre in advance to ensure supply.**	• More limited marketing opportunity than organic, but this is shifting with the expansion of Better Cotton Initiative. • Better Cotton Initative is not generally noted in POS materials, but on company CSR websites.	• Lower price than organic; only slightly more expensive than conventional. • Readily available fibre; limited spinners and supply chain participants.
Promote the use of Fairtrade cotton.	**Work with design and marketing to forecast styles and volumes and contract Fairtrade cotton fibre in advance to ensure supply.**	• Strong marketing opportunity since there is wide consumer awareness of "Fairtrade."	• Higher price, less availability. • Forecasting/planning may be required.
Promote the use of natural coloured cotton.	**Work with design and marketing to forecast styles and volumes and contract natural coloured cotton fibre in advance to ensure supply.**	• Limited marketing opportunity due to low consumer awareness and limited colours.	• Higher price, less availability. • Delicate fibre. • Limited supply chain participants (growers, ginners, spinners. • Forecasting required to ensure supply.

AVAILABILITY

All the above-mentioned alternatives to conventional cotton are now available in yarns, and knitted and woven fabrics.

Organic cotton is available in a variety of fabrics from 100% organic cotton to numerous blends with other fibres.

Due to high demand, the availability of organic cotton products is restricted. Forward projections and contracting are essential to secure supply for future seasons.

The first harvest of Better Cotton was in 2010-2011 and was provided by farmers in Brazil, India, Mali and Pakistan. Better Cotton from China should be available from the 2012 harvest onwards, and Turkey is also preparing to produce Better Cotton.[21]

Natural coloured cotton is available in China, Romania and the United States.

APPLICATIONS

Approximately 60% of cotton fibre is used in clothing, most notably in shirts, T-shirts, jeans, coats, jackets, underwear and foundation garments.

Organic and transitional cotton is the same quality as conventional cotton and appropriate for any fabric.

Natural coloured cotton is available only in a narrow range of brown and green colours, but can be grown in a variety of other colours.

MARKETING OPPORTUNITIES

100% organic cotton Do not claim "organic T-shirt" unless all fibres, yarn, trims and dyes used to manufacture the garment met **GOTS** certification standards. "Made from 100% organic cotton" is acceptable if this is verified accurate.

Made with organically grown cotton For products that contain 95% or more organic cotton, as long as the remaining content is not cotton.

biodegradable All fibres, yarns, trims and dyes used to manufacture the product or garment must also be biodegradable, or disassembled before disposal. This should be substantiated with documentation that the product can completely break down into non-toxic material by being processed in a facility where compost accepted. Secondary label or marketing material should be provided to instruct customer.

Cleaner Cotton™ If used.

Better Cotton If used.

Organic in-conversion If used.

natural coloured cotton If used.

Fairtrade If used.

OEKO-TEK® certified If used.

OE Blended standard should use the "Made with X% organically grown cotton," and make reference to the OE Blended Standard. "X" must represent the final percentage of organic cotton by weight in the finished product.

INNOVATION OPPORTUNITIES

1. Experiment with blends of different types of cottons to balance cost and aesthetics: virgin cotton and recycled, organic cotton and conventional, Cleaner Cotton™ and conventional, coloured cotton and white cotton, etc.

2. Explore innovative fabrications that use blends with cotton (Tencel/organic cotton/elastane, for example).

3. Due to higher price of organic fibre, consider designing fashion products that command a higher retail price, rather than designing organic into basic commodities.

4. Consider knitting or weaving coloured cotton yarns with dyed yarns to create more varied products, whilst reducing overall volume of dyes (and associated pollution) for green and brown shades.

5. Blend coloured cotton with white organic to create mélange effects and strengthen the yarn.

6. Partner with Cotton Connect to help your company implement Better Cotton, or another sustainable cotton initiative.[28]

7. Use tags and hangtags to encourage consumers to wash cotton garments in cold water, and tumble dry and iron only when necessary.

8. Develop a concept featuring wrinkled cotton to influence the customer to reduce ironing of the final product and the energy it uses.

9. Create a cotton product that is both 100% biodegradable and 100% compostable: the product can break down in a reasonable amount of time and is equipped with an ingredient that provides valuable nutrients to the soil after disposal.

10. Take a multi-layered approach: combine several of the above opportunities together for a full lifecycle approach.

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RECYCLED COTTON

Using recycled fibres achieves a number of ecological benefits. Most notably, it reduces the depletion of natural resources (i.e. the water and energy embedded in the garment is utilized more than once) and it reduces the textile load on landfills.

NATURAL FIBRE

BENEFITS

Recycled cotton has the potential to ease the pressure of industrialized farming places on the land to yield more virgin fibre. It also reduces impacts associated with dyeing, since the colour from the previous life of the garment remains in the fibre, and avoids emissions associated with disposal in landfill.

Most recycled cotton products are not bleached or dyed, but are used in their existing state. When they are over-dyed recycled fibres incur the usual toxicity, and water and energy impacts associated with dyeing processes.

MORE INFO PART 5: DYEING & PRINTING

Recycled cotton can be created from post-industrial (pre-consumer) or post-consumer waste.

TYPES OF COTTON RECYCLING: POST-INDUSTRIAL WASTE RECYCLING

Post-industrial waste (also known as pre-consumer waste) utilizes material created during product manufacturing. Examples of post-industrial waste include selvage from weaving, fabric remnants, cutting room waste, excess production, inventory and unsold items.

Wasted materials are collected throughout the manufacturing process. Manufactured cotton apparel products typically generate 20-40% waste in the production pipeline (from yarn spinning, weaving and knitting, dyeing and finishing, to cutting and sewing). Of this about 5-10% occurs in the yarn spinning stage (mainly in the form of fibre) and 15-30% occurs after fabric construction (in weaving/knitting, dyeing/printing, and cutting and sewing).

Rather than discarding this waste, manufacturers and mills recycle it within the existing textile manufacturing system. Energy may be required to convert the waste into usable forms, and the waste may be used as a raw material in the textile plant, or may be sold and used for some other purpose unrelated to textiles or apparel, such as stuffing or padding in automobiles, furniture or mattresses, or as raw material for paper or for coarse yarns (e.g., yarn for mop heads, industrial belting, rope, twine), and as insulation.

More than 50% of post-industrial textile waste is reused or recycled in some fashion.

POST-INDUSTRIAL WASTE (ALSO KNOWN AS PRE-CONSUMER WASTE) UTILIZES MATERIAL CREATED DURING PRODUCT MANUFACTURING.

Spinning Waste

Fibre waste from spinning is often segregated into “fibrous waste” and “trashy waste." Fibrous waste contains a high percentage of short fibres, and will ordinarily have reduced strength, which can lead to fibre breakage. When the yarn type and quality demands allow, fibrous waste can be fed back into the production line and blended with incoming virgin fibre, a practice which also reduces costs. The key is consistency and thorough blending to maintain a quality yarn.

Trashy waste is generated by cotton openers/cleaners and cotton carding, and is generally composed of 50% fibres and 50% trash (also called "non-lint"). The trash component usually includes plant leaf, stem, seed particles, bale wrap fragments, etc. Unlike fibrous waste, trashy waste must be processed through a special fibre reclamation machine before reuse. Only a small percentage of yarn spinners have the capability to reclaim fibres from trashy waste.

Cutting room waste, fabric remnants and unsold items

Cutting room waste and fabric remnants can be recycled and returned to fibre form if they are 100% cotton. Garneting is the process by which these forms of waste are shredded to a fluffy, fibrous condition simulating the original condition of the fibre.

For sewn garments, all trims (zippers, buttons, rivets, leather patches, etc.) and heavy/taped, folded and double-stitched seams are removed before garneting. The items are then separated by type and colour, and chopped into small pieces (usually measuring 2-6 square inches). The fabric is then run through a series of high-speed cylinders covered with wire (e.g., saw wire), or steel spikes, until it forms individual fibres.

Since the waste is usually sorted by colour prior to garneting, each resulting bale of recycled fibre is one colour or one colour family. The yarn spinner can create custom shades and heather effects by blending fibres from several different bales together, not unlike the way dyes are used to create tertiary colours.

THE VISUAL EFFECT CAN BE QUITE STRIKING, SINCE COLOURS CREATED THIS WAY HAVE A DEPTH AND LIVELINESS.

Because of its short fibre length, recycled cotton is normally blended with virgin cotton or synthetic fibre to help facilitate processing and add strength to the yarn. A typical blend is around 85% recycled/15% virgin cotton or synthetic fibre. The synthetic fibre used is most often acrylic, because this adds softness to the yarn and the resulting fabric, although polyester (particularly recycled polyester) is becoming more common. By blending recycled cotton with recycled polyester, a 100% recycled product can be produced.

TYPES OF COTTON RECYCLING: POST-CONSUMER WASTE RECYCLING

Used and discarded products (e.g., garments, carpet, automotive upholstery) are collected, deconstructed if necessary, and either recycled and used as raw material in the textile facility or sold and used for some other purpose unrelated to textiles and apparel.

Post-consumer cotton waste tends to be “down-cycled” (converting waste into lower quality products) to non-visible products such as nonwovens and felts for applications in car insulation, roofing felt, loudspeaker cones, fillings, etc. Upcycled garment-to-garment solutions are ideal but are currently complex and costly to develop, since they involve labor-intensive operations and are carried out in rich consumer economies, where labor costs are high.

OPTIMIZE SUSTAINABILITY BENEFITS

- Promote yarn spinners that make optimum use of waste.
- Promote yarn spinners that use trashy waste.
- Promote suppliers who make use of recycled cotton yarns.
- Encourage all manufacturers within the supply chain to reclaim and recycle raw materials. Bring together supply chain partners to make the use of recycled materials more convenient and less expensive.
- Minimize, to the extent possible, transport of the waste.
- Ensure that there is proper validation that the material being used would have otherwise gone into the waste stream.

AVAILABILITY

Though the availability of recycled cotton for textiles is limited today, this is likely to increase as virgin resources and landfills become more restricted and new recycling innovations are developed.

Several projects and sources for recycled fabrics already exist in the United States, India, Japan, China and Europe.

END USE

Post-industrial waste is reused by the textile industry and spun into yarns with new apparel applications.

Post-consumer waste is mostly reused in nonwovens and felts, insulation materials, linings, furniture padding and filling and paper manufacturing.

MARKETING OPPORTUNITIES

Post-industrial recycled cotton With certification.

Post-consumer recycled cotton With certification.

Regulations require the percent of post-consumer and post-industrial recycled content to be stated clearly.

INNOVATION OPPORTUNITIES

1. Create merchandising and marking opportunities to turn any negative associations with recycled yarns into positive stories.
2. Design products that feature the unique, heathered or tweed characteristics of recycled cotton.
3. Create stripes with recycled cotton blends and virgin cotton for heather/solid effects.
4. Develop "closed-loop" opportunities, such as collecting waste from your company's textile or apparel producers and re-using that waste in new products.
5. Develop a "tri-blend" of recycled cotton, recycled polyester and virgin cotton that meets technical requirements and brings a unique aesthetic to products.
6. Develop garments that are designed to be easily deconstructed to enable a retail take-back and recycling program. Experment with seaming, and a variety of disassembly mechanisms in different fabrics.

"Beginner's Guide to Sustainable Fibres," Textile Exchange, 2011

FLAX LINEN

Flax is a fast and easy growing annual, which requires a cool and relatively humid climate.[1] In its growing and processing, flax has minimal impacts on the environment in comparison to other fibres. Linen, the fabric derived from the flax plant, may offer a more sustainable alternative to cotton and polyester.

NATURAL FIBRE

BENEFITS

Flax is a good rotation crop, grows quickly and requires few chemical inputs in its cultivation.[1] Some sources state that flax production requires half the volume of pesticides per acre compared to that of conventional cotton.[2] In addition, flax is a rain fed crop and generally doesn't require **irrigation**.[3]

FAST-GROWING RENEWABLE FIBRES

FIBRE	LENGTH	TIMING
Flax	1 meter	3-4 months[5]
Jute	1-4 meters[4]	3-4 months[6]
Hemp	4 meters	3 months[7]
Bamboo	24 meters	40 days[8]

Flax may be grown organically, and when claimed "**organic**" must meet the standard certification requirements by an internationally recognized certification agency accredited by **International Federation of Agriculture Movements (IFOAM)**.

Flax fibre has a high natural luster and its natural colour ranges from beige to light tan to grey.[1]

Once the fibre is extracted from the stem, processing flax into yarn is largely mechanical, with minimal environmental impact.

Flax fibre and the resulting linen fabric have unique thermo-regulating properties, providing insulation in the winter and good breathability and a cool feeling in the summer.[1]

In 100% form, linen from flax fabric is **biodegradable** after its useful life, though absolute biodegradability depends on the dyes and trims used, and route of disposal.

MORE INFO APPENDIX: BIODEGRADABILITY

FLAX FIBRE AND THE RESULTING LINEN FABRIC HAVE UNIQUE THERMO-REGULATING PROPERTIES.

POTENTIAL IMPACTS

CULTIVATION

Flax does require herbicides to control weeds and, as a cellulosic fibre, it also requires some fertilizers. Synthetic fertilizers contain nitrogen salts which salinate the soil and over the long term decrease the productivity of the soil and pollute aquatic ecosystems.

PROCESSING

Flax is a bast fibre and is extracted directly from the stalk of the plant in a process similar to that used for jute, hemp and bamboo for linen. The fibre is extracted through a process called retting, which separates the fibre from the stems using microorganisms and moisture. This is carried out in the field (as with dew retting) or in tanks (water or chemical retting). Dew retting is preferred as it utilizes the natural moisture of dew, but is the longest process, taking over 2-3 weeks to break down the stems slowly. Although chemical retting is the fastest process, the wastewater is concentrated and rich in chemicals and biological matter, which negatively impacts receiving water bodies, harming aquatic ecosystems, if left untreated before its release.[9]

DEW RETTING USES THE NATURAL MOISTURE OF DEW, BUT IS THE LONGEST PROCESS, TAKING OVER 2-3 WEEKS TO BREAK DOWN THE STEMS.

RETTING PROCESS COMPARISION CHART[9]

TYPE	DESCRIPTION	ADVANTAGE	IMPACTS	DURATION
Dew Retting	Plant stems are cut or pulled out and left in the field to rot.	Returns nutrients back into the soil.	Reduced fibre strength; low and inconsistent quality; influenced by weather; product is contaminated with soil.	2–3 weeks
Water Retting	Plant stems are immersed in water (rivers, ponds or tanks) and monitored frequently.	Produces fibre of greater uniformity and higher quality.	Extensive stench and pollution arising from anaerobic bacterial fermentation of the plant; high cost; low-grade fibre. Requires water treatment maintenance.	7–14 days
Chemical Retting	Boiling and applying chemicals, normally sodium hydroxide, sodium benzoate, hydrogen peroxide.	More efficient and can produce clean and consistent long and smooth surface bast fibre within a short period of time.	Unfavorable colour; high processing cost. The wastewater is concentrated and rich in chemicals and biological matter, which negatively impacts receiving water bodies, harming aquatic ecosystems, if left untreated before its release.	60 – 75 minutes

DYEING

The natural colour of flax fibre is beige, and flax yarn or fabric must be bleached with chlorine to render it light enough to receive dyes for light or clear shades. Chlorine bleach can form halogenated organic compounds in the wastewater. These compounds bioaccumulate in the food chain, are known **teratogens** and **mutagens**, are suspected **human carcinogens** and cause reproductive harm.

MORE INFO PART 5: DYEING & PRINTING

CONSUMER CARE/ WASHING

Linen (from flax) may be washed or dry-cleaned. Electricity and water use in the care of the garment can cause significant environmental impacts. Moreover, linen from flax wrinkles easily and requires heavy pressing to render it smooth after wash. This uses significant amounts of electrical energy over the long term.

MORE INFO APPENDIX: CONSUMER CARE & WASHING

LINEN FROM FLAX WRINKLES EASILY AND REQUIRES HEAVY PRESSING. THIS USES SIGNIFICANT AMOUNTS OF ELECTRICAL ENERGY OVER THE LONG TERM.

END OF USE

Although 100% flax fibre is claimed to be biodegradable, the amount of time it could take for a flax product to decompose naturally and in a short period of time is dependent upon a number of conditions—including how much air, temperature and sunlight the fibre is exposed to. If the waste is buried in a landfill, it can take even longer for it to break down.[10]

MORE INFO APPENDIX: BIODEGRADABILITY

AVAILABILITY

70% of the world's crop is produced in Europe; 10,000 companies from 14 European Union countries cover all stages of the fibre's production and transformation.[12] Europe produces 1299 tonnes of European Flax® annually.[12]

Dew retted linen from flax is readily available, though has to be specially requested. Certification on the retting method used should also be requested.

Organic linen from flax is less available and more expensive than conventional linen from flax. Organic certification by an internationally recognized certification agency accredited by **IFOAM** must be in place.

APPLICATIONS

In 100% fabrications, linen from flax is durable and available in a variety of yarn counts and fabric types. Suitable product applications include jeans, dress pants, jackets, dress shirts, handkerchief-weight blouses, knits, bed linens and outdoor fabrics. Blends of cotton/linen from flax are machine washable and suitable for sportswear, wovens and knits.

OPTIMIZE SUSTAINABILITY BENEFITS

OPPORTUNITY	BENEFITS	CONSIDERATIONS
Promote suppliers using organic flax.	Ensures that no disallowed fertilizers are used.	• Organic certification must be in place by a recognized international certification agency accredited by **IFOAM**. • Organic linen from flax is not as readily available as conventional linen from flax, and commands a premium.
Promote the use of natural colour.	No bleaches or dyes are used in this case, and associated pollution impacts are avoided.	
Promote the use of non-chlorine bleaches, such as hydrogen peroxide, to lighten the natural beige colour for dyeing dark shades and bright/light shades.	Hydrogen peroxide harmlessly decomposes into water and oxygen gas. MORE INFO PART 5: BLEACHING	• Non-chlorine bleaches do not strip out the original colour of the fibre. Consequently, lighter and brighter colours will be duller due to the over-dyed effect. Non-chlorine bleaching is adequate for dark colours, which mask the original beige tone.
Promote the use of ozone bleaching processes to strip out the natural beige colour of flax linen. **Promote the particular aesthetic of ozone bleach effects.**	Ozone can be used with no water at all. MORE INFO PART 5: BLEACHING	• Ozone has limited availability, and is relatively expensive since it requires investment in ozone generating equipment. • Ozone processes produce a different aesthetic than chlorine derivative or permanganate bleaching.

OPPORTUNITY	BENEFITS	CONSIDERATIONS
Promote the use of enzymes to strip out the natural beige colour of linen from flax. **Promote the particular aesthetic of enzyme bleaches.**		• Enzymes are not allowed in **GOTS** standards. • Enzymes produce a different aesthetic than chlorine derivative or permanganate bleaching.
Promote suppliers who use dew retting over water or chemical retting.	Dew retting reduces the biological load in the receiving water bodies, and adds nutrients to the soil.	• The natural colour may vary slightly from lot to lot, since the process is influenced by weather.
Promote suppliers who use enzymatic retting over water or chemical retting.	Process is faster and leaves the water unharmed. Can be commercially reproduced.	• Low fibre strength. • Process is less common compared to other retting processes.
Promote the use of European Flax®.	Ensures that crop is rain fed, disallows use of GMO seed and ensures retting process does not pollute water.[11]	• Does not consider environmental impacts from dyeing, transportation, consumer care and disposal/end of use. • Not necessarily organic.
Actively seek out stain-resistant finishes for flax linen.	Will reduce washing, ironing and dry-cleaning by the consumer, and the water and pollution associated with consumer care.	

MARKETING OPPORTUNITIES

fast-growing natural resource

low water footprint in cultivation

organic If organic flax fibre is used. All fibres, yarn, trims and dyes used to manufacture the garment must comply with the **GOTS** organic garment standard. Simply state "made from 100% organic flax," if this is verified and accurate.

biodegradable All fibres, yarns, trims and dyes used to manufacture the product or garment must also be biodegradable, or disassembled before disposal. This should be substantiated with documentation that the product can completely break down into non-toxic material by being processed in a facility where compost is accepted. Secondary label or marketing material should be provided to instruct customer.

non-chlorine bleached If alternative bleach is used.

dew retted If dew retted processed.

enzyme retted If enzyme retted processed.

European Flax® If European Flax is used.

INNOVATION OPPORTUNITIES

1. Use linen from flax fibre in blends with cotton to achieve grey/beige heather effects, then over-dye the cotton side to achieve heathered colours without using chlorine bleach.

2. Use 100% flax linen in stripes with cotton, then over-dye to achieve tonal colours without using chlorine bleach.

3. When used in 100% form, design "culturally durable" (i.e., styling that doesn't date with passing trends) products in linen from flax to optimize the fibre's physical durability.

4. Since linen from flax wrinkles easily, and washing and caring for the garment can cause significant environmental impacts, design garments that utilize the natural wrinkling of the fabric as a design feature to influence the customer to reduce ironing of the final product and the energy it uses.

5. Create a flax product that is 100% **biodegradable** and **compostable**: the product can break down in a reasonable amount of time and is equipped with an ingredient that provides valuable nutrients to the soil after disposal.

6. Encourage handwashing or spot cleaning on the hangtag and labeling/POS to influence the consumer to take an active role in reducing environmental impacts of linen from flax garment/product care.

1. "Beginner's Guide to Sustainable Fibres," Textile Exchange, 201
2. "The Linen Shirt Eco Profile," Bio Intelligence Service, February 2008. http://www.saneco.com/IMG/pdf/linen_shirt_eco-profile.pdf http://www.thehindubusinessline.com/industry-and-economy/agri-biz/govt-may-use-wastelands-for-tasar-silk-cultivation/article4479274.ece
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11. Ensures that crop is rain fed, and disallows use of GMO seed.
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JUTE

Jute has a reputation as a sustainable fibre. In 100% form, it is biodegradable, with relatively harmless processing. Although jute is generally used for sacks and bags, it represents an opportunity in other applications to feature its sustainable qualities.

NATURAL FIBRE

BENEFITS

Jute is a natural **bast** fibre along with kenaf, hemp, ramie, bamboo and flax.

Jute fibre and fabric are often called Hessian. Jute sacks are called Gunny Bags in some European countries. In North America, the fabric made from jute is known as Burlap. In Spanish, jute is called Yute and jute fabrics are called Arpillera.

Jute is a long, soft, shiny plant fibre that can be spun into coarse, strong threads.

JUTE IS ONE OF THE MOST INEXPENSIVE NATURAL FIBRES AND IS SECOND ONLY TO COTTON IN THE AMOUNT PRODUCED AND VARIETY OF USES.[1]

Jute is a fast-growing renewable fibre that is annually farmed. Jute will grow to a length of 1 to 4 meters in 3 to 4 months.[2] Jute is a biologically efficient, low maintenance crop that requires few chemical inputs during the growing season. It is mainly rain fed, traditionally farmed and grown similarly to organic produce.[3]

Jute has a natural luster and is valued for its durability, fair abrasion resistance, and high tensile strength. Jute fibre has anti-static properties, heat insulation and low elongation, which helps to retain its shape. Jute fibre is colour- and light-fast.

Jute may be grown organically, but must meet the certification requirements of an internationally recognized certification agency accredited by **International Federation of Agriculture Movements (IFOAM)**.

FAST-GROWING RENEWABLE FIBRES

FIBRE	LENGTH	TIMING
Flax	1 meter	3-4 months
Jute	1-4 meters	3-4 months
Hemp	4 meters	3 months[4]
Bamboo	24 meters	40 days[5]

Studies reveal that the CO2 assimilation rate of jute is several times higher than that of trees. During the jute growing period, one hectare of jute plants can absorb about 15 metric tonnes of CO2 from the atmosphere and release about 11 metric tonnes of oxygen.[6]

In 100% form, jute is biodegradable. Although collective data does not exist regarding how long it takes for jute to fully decompose, one source reports that jute will completely break down in 2 to 3 years (as apposed to polyester which can take anywhere from 40 to 1000 years to break down).[7]

Due to its extensive root system, jute can help reduce soil loss and erosion and is particularly suitable for crop rotation. Since the leaves of the plant are left in the field after harvest, the nitrogen they contain absorbs into the soil and food crops can be grown immediately without having to leave the fields fallow.[8]

Once the jute fibre is extracted from the stem, processing it into yarn is largely mechanical with minimal environmental impact.

POTENTIAL IMPACTS

PROCESSING

Jute is a bast fibre and is extracted directly from the stalk of the plant in a process similar to that used for flax, hemp and bamboo (for linen). The fibre is extracted through a process called retting, which separates the fibre from the stems using microorganisms and moisture. This is carried out in the field (with dew retting) or in tanks (water or chemical retting). Dew retting is preferred as it utilizes the natural moisture of dew, but is a longer process, taking 2 to 3 weeks to break down the stems slowly. Although chemical retting is a faster process, the wastewater is concentrated and rich in chemicals and biological matter, which negatively impacts receiving water bodies and aquatic ecosystems if left untreated before its release.[9]

Although organic certification disallows the use of chemicals in the growing of jute, it does not necessarily guarantee low water use, fair labor practices or a fair price to the farmer.

DYEING, BLENDING AND TREATMENTS

The natural colour of jute fibre is beige, and jute yarn or fabric must be bleached with chlorine to render it light enough to receive dyes for light or clear shades. Chlorine bleach can form halogenated organic compounds in the wastewater. These compounds bioaccumulate in the food chain, are known **teratogens** and **mutagens**, are suspected **human carcinogens** and cause reproductive harm.

Jute can also be blended with wool. By treating jute with caustic soda (also called "lye"), crimp, softness, pliability and appearance is improved, aiding in its ability to be spun with wool. Due to its toxic nature, even a small quantity of caustic soda in a diluted solution can cause skin burns or injure the eyes, causing blindness.[11]

CONSUMER CARE/WASHING

Jute may be washed or dry-cleaned. Electricity and water use in the care of the garment can cause significant environmental impacts. Moreover, jute wrinkles easily and requires heavy pressing to render it smooth after wash. This uses significant amounts of electrical energy over the long term.

MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

Although 100% jute fibre is **biodegradable**, the amount of time it could take for a jute product to decompose naturally and in a short period of time is dependent upon a number of conditions—including how much air, temperature and sunlight the fibre is exposed to. If the waste is buried in a landfill, it can take even longer for it to break down.

MORE INFO APPENDIX: BIODEGRADABILITY

RETTING PROCESS COMPARISION CHART

TYPE	DESCRIPTION	ADVANTAGE	IMPACTS	DURATION
Dew Retting	Plant stems are cut or pulled out and left in the field to rot.	Returns nutrients back into the soil.	Reduced fibre strength; inconsistent quality; influenced by weather; and product is contaminated with soil.	2–3 weeks
Water Retting	Plant stems are immersed in water (rivers, ponds or tanks) and monitored frequently.	Produces fibre of greater uniformity and higher quality.	Extensive stench and pollution arising from anaerobic bacterial fermentation of the plant; high cost; low-grade fibre. Requires water treatment maintenance.	7–14 days
Chemical Retting	Boiling and applying chemicals, normally sodium hydroxide, sodium benzoate, hydrogen peroxide.	More efficient and can produce clean and consistent long and smooth surface bast fibre within a short period of time.	Unfavorable colour; high processing cost. The wastewater is concentrated and rich in chemicals and biological matter, which negatively impacts receiving water bodies, harming aquatic ecosystems, if left untreated before its release.	60 – 75 minutes

OPTIMIZE SUSTAINABILITY BENEFITS

OPPORTUNITY	BENEFITS	CONSIDERATIONS
Promote suppliers using organic jute.	In addition to the general ecological benefits of jute, organic processes ensure that no disallowed pesticides or fertilizers are used.	• Organic certification must be in place by a recognized international certification agency accredited by **IFOAM**. • Organic jute is not as readily available as conventional jute, and commands a premium.
Promote the use of natural colour jute.	No bleaches or dyes are used in this case, and associated pollution impacts are avoided.	
Promote suppliers who use dew retting over water or chemical retting.	Dew retting reduces the biological load in the receiving water bodies and adds nutrients to the soil.	• The natural colour may vary slightly from lot to lot, since the process is influenced by weather.
Promote suppliers who use enzymatic retting over water or chemical retting.	Process is faster and leaves the water unharmed. Can be commercially reproduced.	• Low fibre strength. Process is less common compared to other retting processes.
Use hydrogen peroxide to lighten the natural beige colour for dyeing dark shades and bright/light shades.	Hydrogen peroxide harmlessly decomposes into water and oxygen gas.	• Non-chlorine bleaches do not strip out the original colour of the fibre. Consequently, colours will be duller due to the over-dyed effect. Non-chlorine bleaching is adequate for dark colours, which mask the original beige tone.
Use ozone bleaching processes to strip out the natural beige colour of jute. **Promote the particular aesthetic of ozone bleach effects.**	Ozone can used be with no water at all.	• Ozone has limited availability, and is relatively expensive since it requires investment in ozone generating equipment. • Ozone processes produce a different aesthetic than chlorine derivative or permanganate bleaching.
Promote the use of enzymes to strip out the natural beige colour of jute. **Promote the particular aesthetic of enzyme bleaches.**	MORE INFO PART 5: BLEACHING	• Enzymes are not allowed in **GOTS** standards. • Enzymes produce a different aesthetic than chlorine derivative or permanganate bleaching.
Promote the use of jute-blended fabrics.	Can achieve the property benefits of both fibres.	• Sometimes requires further processing, which could include chemicals.
Know the difference between natural jute fabric and jute made from a viscose process.	Viscose made from jute is chemically processed and has greater pollution impacts to water and air.	MORE INFO PART 3: VISCOSE (FROM BAMBOO)

JUTE FIBRE IS SUITABLE FOR JACKETS AND SKIRTS.

Carven 100% Jute Jacket

AVAILABILITY

Jute is readily available in 100% form as well as blends with wool and silk.

About 95% of the world's jute is grown in India and Bangladesh. Nepal, Myanmar, China, Thailand, Vietnam and Brazil also produce jute. Pakistan imports a substantial amount of raw jute from Bangladesh for processing.[12]

A number of farmers in Bangladesh are currently growing organic jute. Organic certification by an internationally recognized certification agency accredited by **IFOAM** must be in place.

APPLICATIONS

In 100% form, jute is highly durable and suitable for many applications including twine and rope, sackings, carpets, wrapping fabrics (cotton bale), and the construction fabric manufacturing industry. It can be used in curtains, chair coverings, carpets and carpet backing, rugs, and backing for linoleum. Other uses include espadrille shoes.

Jute can be used in home textiles, either replacing cotton or wool or blending with it.

Finest jute threads can be separated out and made into imitation silk.

In 100% form and fabric blends, jute fibre is suitable for jackets and skirts.

MARKETING OPPORTUNITIES

fast-growing natural resource

low water footprint in growing

biodegradable (depending on dyes and trims used) All fibres, yarns, trims and dyes used to manufacture the product or garment must also be biodegradable, or disassembled before disposal. This should be substantiated with documentation that the product can completely break down into non-toxic material by being processed in a facility where compost is accepted. Secondary label or marketing material should be provided to instruct customer.

non-chlorine bleached If alternative bleach is used.

organic All fibres, yarn, trims and dyes used to manufacture the garment must comply with the **GOTS** organic garment standard. Simply state "made from 100% organic jute" if this is verified and accurate.

INNOVATION OPPORTUNITIES

1. As an alternative to plastic bags, develop a 100% biodegradable jute bag (undyed with biodegradable trims) with instructions to the customer on proper disposal.

2. Create a jute product that is 100% **biodegradable** and **compostable**: the product can break down in a reasonable amount of time and can provide valuable nutrients to the soil.

3. Use jute fibre in blends with cotton to achieve grey/beige heather effects, then over-dye the cotton side to achieve heathered colours without using chlorine bleach.

4. Use 100% jute in stripes with cotton, then over-dye to achieve tonal colours without using chlorine bleach.

5. Strategically place jute at places of high stress on products, such as the knees or elbows, to maximize its physically durable properties.

6. Ease effects of cotton growth and cultivation by replacing jute with cotton in applications for denim.

7. Develop garments and products that are designed to be easily deconstructed to enable a take-back and recycling program. Experiment with seaming and a variety of disassembly mechanisms in different fabrics.

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SILK

Silk can play a strategic roll in sustainable textiles for the company. At this high end of the market, silk products may offer greater price elasticity at retail with greater potential to absorb the typically higher costs of sustainable fibres.

NATURAL FIBRE

Silk is a protein fibre produced by silkworms. As a silkworm develops into an adult it feeds on leaves and then spins a cocoon from one continuous silk strand or filament, approximately 914 meters yards long. Inside the cocoon the worm changes into a chrysalis, then into a moth, which then seeks to leave the chrysalis.[1] The moth achieves an escape path by secreting a liquid, which dissolves a hole in the cocoon through which the moth can then escape.[2]

Heat is used to soften the hardened filaments so they can be unwound. Single filaments are then combined with a slight twist into one strand, a process known as filature or "silk reeling."

BENEFITS

Silk is a **renewable natural resource** and **biodegradable** in 100% form. Since the silk filament is a continuous thread it has great tensile strength. In woven fabrics, silk's triangular structure acts as a prism that refracts light, giving silk cloth its highly prized "natural shimmer."[2]

Silk has good absorbency, low conductivity and dyes easily.[2]

Being a natural fibre, silk is readily biodegradable after its useful life, though absolute biodegradability depends on the dyes and trims used, and route of disposal.

The silkworms used for wild or "tussah," or "tasar" feed on leaves, not necessarily mulberry, and does not harm the chrysalis. Tussah silk is derived from cocoons collected after the moth has emerged naturally in the field. Because the continuous silk fibre is broken into smaller pieces as the moth leaves the cocoon, wild silk has a rougher and slubbier surface than cultivated silk.[3]

Sericulture (silk farming) is labor-intensive. About 1 million workers are employed in the silk sector in China. Sericulture provides income for 700,000 households in India, and 20,000 weaving families in Thailand. Wild silk can provide a year round income for tribal people in India and some areas of China.[4]

ABOUT 1 MILLION WORKERS ARE EMPLOYED IN THE SILK SECTOR IN CHINA.

POTENTIAL IMPACTS

ANIMAL WELFARE

On domesticated silk farms the chrysalis is killed to prevent the moth from making a hole in the cocoon. The reason for this is that the hole breaks the highly prized long silk filament into thousands of short lengths, which are useless for higher quality spinning.

PROCESSING

Cocoons are soaked in sodium carbonate to soften in preparation for reeling (unwinding the filament from the cocoon). Silk fabric is then woven with the natural gum or sericin still on the yarn, acting as a natural sizing agent. After weaving, the gum is removed by boiling the fabric in alkali. This can result in a 20% reduction of the harvested weight of the silk. Some of this lost weight is added back by saturating the silk fabric in a bath of tin-phosphate-silicate salts. These processes can create a high biological load on the water, and deplete available oxygen for aquatic species if left untreated. Exposure to tin through breathing and skin contact can have acute and long-term effects on worker health if proper equipment is not used.[6]

Lightweight silk fabrics (fine gauge silk) are prone to wear and are degraded by exposure to sunlight and hot temperatures. They can also be susceptible to abrasion and twisting in laundering.[7]

DYEING

The dyeing processes for silk involve standard industry chemicals and water use. Certain types of dyes are suspected carcinogens and mutagens, and untreated dye water can negatively impact receiving water bodies and harm aquatic ecosystems if left untreated before its release.

MORE INFO PART 5: DYEING & PRINTING

CONSUMER CARE/ WASHING

Due to the delicacy of the fabric, silk products are typically handwashed or dry-cleaned. Washing and caring for any product can cause significant environmental impacts due to chemicals used in cleaning products. Certain chemicals used in dry-cleaning and at-home products have been reported to have detrimental affects on humans and the environment, contribute to ozone depletion and can pollute wastewater.

Silk tends to crush and wrinkle easily. This wrinkling creates a need to increase the frequency of ironing. This can use significant amounts of electrical energy over the long term.

MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

Although 100% silk fibre is **biodegradable**, the amount of time it could take for a silk product to decompose naturally and in a short period of time is dependent upon a number of conditions—including how much air, temperature and sunlight the fibre is exposed to. If the waste is buried in a landfill, it can take even longer for it to break down.[8]

MORE INFO APPENDIX: BIODEGRADABILITY

OPTIMIZE USTAINABILITY BENEFITS

OPPORTUNITY	BENEFITS	CONSIDERATIONS
Promote the use of wild or "Tussah" silk.	• Wild silk doesn't require the chrysalis to be killed. • Wild silk provides a year round income for tribal people in India and some areas of China.[4]	• Due to the shorter (less prized) fibre length, wild/Tussah silk is less expensive than domesticated silk. Tussah silk fabrics have a coarser texture and are typically stiffer and heavier than domesticated silk. • Wild/Tussah silk is available in small quantities.
Promote the use of Ahimsa silk.[9]	• Cultivated in India and doesn't require the chrysalis to be killed. • The fibres are spun into "slubby threads" instead of reeled. • The quality of Ahimsa silk is softer and finer in comparison to regular silk and has a pearl matte natural finish.	• More costly than regular silk due to its laborious process of spinning the many pieces of yarn into one continuous thread. • Not all slubby silks are Ahimsa silk. • Manufacturers often label these slubby silks as Dupioni or shantung, and claim they are Ahimsa silk. This should be substantiated with documentation.
Promote the use of Organic silk.	• Since pesticides are rarely used on silk fibre production (this would kill the silk worm), the main benefit of organic certification is using organically cultivated mulberry bushes. • Organic cultivation has wide ranging benefits for the surrounding ecosystem.	• Organic silk is available in small quantities and carries a price premium. • Certification of organic silk must be in place by an internationally recognized certification agency accredited by **International Federation of Agriculture Movements (IFOAM)**.
Promote the use of Fairtrade silk.	• Ensures the proper treatment of workers.	• Fairtrade silk products are less available then conventional silk. Does not necessarily mean "**organic**."
Blend silk with organic cotton, organic wool, organic linen, etc.	• Brings a "luxury" element to the product and commands a higher retail price. • Blending with a washable fibre reduces the impact of consumer care/dry-cleaning	

AVAILABILITY

China produces about 70% of the world's silk, followed by Brazil, India, Thailand and Vietnam, with minor production in Turkmenistan and Uzbekistan. India, Italy and Japan are the main importers of raw silk for processing.[2]

Organic silk is available in small quantities at premium prices. Certification of organic silk must be in place by an internationally recognized certification agency accredited by **IFOAM**.

Most wild silk is cultivated in China, India and Japan.[3] Verification of the source of the wild silk must be provided.

Ahimsa silk is cultivated in India.

END USE

Silk's natural beauty and other properties—such as comfort in warm weather and warmth during colder months— have made it sought after for use in high-fashion clothes, lingerie and underwear.[2]

Due to its coarseness, wild silk is largely used in furnishings and interiors.[3]

MOST WILD SILK IS CULTIVATED IN CHINA, INDIA AND JAPAN.[3] VERIFICATION OF THE SOURCE OF THE WILD SILK MUST BE PROVIDED. AHIMSA SILK IS CULTIVATED IN INDIA.

MARKETING OPPORTUNITIES

fairtrade/artisan wild silk When developed through a nonprofit organization and source is verified.

wild silk With verification of source in place.

ahimsa silk With verification of source in place.

renewable natural resource

biodegradable All fibres, yarns, trims and dyes used to manufacture the product or garment must also be biodegradable, or disassembled before disposal. This should be substantiated with documentation that the product can completely break down into non-toxic material by being processed in a facility where compost is accepted. Secondary label or marketing material should be provided to instruct customer.

organic If organic silk is used.

alternative dyes If used.

handwash in cold water or spot clean instead of dry-clean Can save significant amounts of electrical energy over time.

INNOVATION OPPORTUNITIES

1. Encourage handwashing or spot cleaning on the hangtag and labeling/POS to influence the consumer to take an active role in reducing environmental impacts of silk garment care.

2. Wild silk is an important peasant industry in India, and areas of China. An artisan project would bring an additional social/fairtrade element to a sustainable fabric program.

3. Blending with another fibre that is washable, such as cotton, reduces the impact of consumer care/dry-cleaning.

4. Design garments that utlilize the natural wrinkling of silk as a design feature to influence the customer to reduce ironing of the final product and the energy it uses.

5. Create a silk garment that is 100% **biodegradable**: the product is either undyed or natural-dyed, with biodegradable trims and thread, and is equipped with secondary label or marketing material that instructs the customer on how to dispose.

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WOOL

Wool is the textile fibre obtained from sheep and certain other animals, including goats, rabbits, sheep and camels. Wool fibre has inherent sustainability attributes. It is a renewable, natural fibre that can be used as a viable alternative to synthetic fabrics.

NATURAL FIBRE

BENEFITS

Wool is a natural fibre and renewable. It is valued for its natural warmth and water repellence.

Merino, cashmere, mohair, alpaca, camel, and angora wools are all valued for their softness, comfort, wrinkle resistance and luster. Mohair and alpaca are even naturally non-pilling.

The surface of wool fibre is water- dirt- and stain-repellent, whilst the fibre interior is highly moisture absorbent, making it a comfortable fabric to wear.

WOOL IS NATURALLY FIRE RETARDENT. SINCE THERE IS NO NEED FOR THE USE OF FIRE RETARDANT COATINGS OR SYNTHETIC TOPICAL FINISHES ON WOOL, IT MAY BE USED AS A VIABLE ALTERNATIVE TO SYNTHETIC FABRICS.

Wool absorbs odours and for this reason, is considered self-cleaning. Wool tends not to smell bad, even after long periods of wear. Because of this, wool garments do not need to be washed frequently.[1]

In 100% form, wool fabric is **biodegradable** after its useful life, though absolute biodegradability depends on the dyes and trims used, and route of disposal.

WOOL ABSORBS ODOURS AND IS, TO SOME EXTENT, SELF CLEANING.

WOOL TYPES AND CHARACTERISTICS

	MERINO	CASHMERE	MOHAIR	CAMEL	ANGORA
					
Microns	18-20	14-19	23-45	16-20	14-16
Source & exclusivity	Sheep; common	Cashmere goat; common	Angora goat; common	Two-humped Bactrian camel; rare	Angora rabbit; limited producers
Major producers	Australia, China, New Zealand, Iran, Argentina, UK	India, Mongolia, China	South Africa, United States	Mongolia, China	China, Europe, Chile, United States
Fibre collection	Shearing	Combing or Shearing	Shearing (twice annually)	Combed, shorn or collected during the 6-8 weeks moulting season	Hair removed every 3 months by shearing or gentle plucking
Cost	Low–moderate	High–luxury fibre	High	High–luxury fibre	High–luxury fibre
Blends well wih	Natural and synthetic fibres	Wool and nylon (for knitwear)	Wool	Cashmere, wool, nylon (to make it more economical for manufacturer to produce)	Wool (to increase warmth and enhance softness)
End use	Outerwear, knitwear, activewear, durable upholstery	Knitwear, babywear, blazers, coats, underwear, sleepwear, rugs, carpets	Clothing, rugs, carpets, blankets, durable upholstery	Knitwear garments, coats, suits, blazers, jackets, gloves, hats, scarves	Luxury undergarments, underwear, thermal base layers, scarves, sportswear, sweaters
Natural colours	White, brown, grey, charcoal, black	White, grey, brown, red, yellow, almond, apricot	Blacks, greys, silvers, reds, apricots, copper	Golden tan, red to light brown	Black, blue, chocolate, brown, greys, white, reds
Consumer care & washing	Hand-washable	Dry-clean	Dry-clean	Dry-clean	Hand-washable

POTENTIAL IMPACTS

CULTIVATION/ANIMAL WELFARE:

Wool from sheep

Merino sheep have been specially bred to produce more volume of higher quality wool than other breeds. This is enabled by their convoluted skin, which provides a greater surface area on which more fibre can be grown. But some reports indicate that the increased weight of wool can strain the sheep and lead to heat stroke, dehydration and even death. In addition, urine and moisture tend to build up in the wrinkles of the skin, attracting flies, particularly the blowfly, and maggots around the sheep's rump. A compensation procedure known as mulesing involves carving skin from the back legs of the sheep to make the area smoother and less prone to flies.

Mulesing has been a hotly debated subject amongst activist groups and the textile industry as a whole. Activist reports note significant cruelty to animals during this procedure, whereas advocates describe mulesing as "a very cost-effective and simple way" to protect against flystrike, says Wool Producers Australia president Geoff Power. There have been brand boycotts and country-wide phase-out plans of mulesing, but some farmers in Australia report mulesing to still be the most cost-effective approach.[2]

Alternatives to mulesing to prevent flystrike include spray-on chemicals. These chemicals can be harmful to humans if the proper protective equipment is not worn, and can contaminate receiving water bodies if not disposed of properly.[3]

INTENSIVE SHEEP AND CASHMERE GOAT OVERGRAZING HAS CONTRIBUTED TO LAND DEGRADATION IN SOME REGIONS.

All breeds of sheep are treated with pesticides (organophosphates and pyrethroids) to control lice and parasites. These chemicals may be applied directly to the fleece or by submerging the sheep into chemical solution pools (sheep dips).

Repeated exposures to organophosphate pesticides are linked to severe nerve damage in humans, and when poorly managed, these chemical agents may contaminate regional water systems. Pyrethroids in particular are extremely toxic to aquatic life.

Besides these fibre-specific impacts, intensive sheep ranching has contributed to land degradation in some regions.

POTENTIAL IMPACTS cont'd

CULTIVATION/ANIMAL WELFARE:

Cashmere from goats

Although a profitable source of income for farmers, the impact of overgrazing of cashmere goats has reportedly contributed to land degradation and **desertification**, and as a result loss of **biodiversity** in Mongolia and other countries. This is because goats are insatiable eaters compared to other livestock, and consume the root of the grass, thereby stopping it from growing altogether. To accommodate the growing cashmere industry, and the resulting drop in cashmere prices, farmers increase the size of their herds to compensate, therefore increasing the impact on land. [4]

There is little reliable information supporting animal cruelty to cashmere goats. However, due to increased consumer demand for cashmere, overall consumer demand for inexpensive products, increase in herd size, and lack of standards regulating proper treatment of animals in cashmere-producing countries, relationships with producers should be closely monitored to ensure friendly practices are being implemented.

Angora wool from rabbits

Animal cruelty to Angora rabbits in China has been recently publicized. Typically, angora rabbits are either shorn or gently plucked of their wool every 3 months. Recent undercover video footage has shown Chinese farmers vigorously ripping out fibre from the rabbit's body. The reason for this is that these farmers receive a higher price for the entire length of the hair. Several companies have ceased production of angora products in response to the allegations. Relationships with producers should be closely monitored to ensure friendly practices are being implemented.

RELATIONSHIPS WITH ANGORA PRODUCERS SHOULD BE CLOSELY MONITORED TO ENSURE FRIENDLY PRACTICES ARE BEING IMPLEMENTED.

POTENTIAL IMPACTS cont'd

PROCESSING:

Scouring

Around two-thirds of the weight of the wool fibre by weight is grease, dried sweat salts, skin flakes, dirt and dried plant matter. To remove these substances from the wool fibre, a cleaning or scouring process is carried out at hot temperatures (approx. 60-66º C) in an aqueous solution of sodium hydroxide and detergent.[5] Scouring consumes large amounts of water, and produces an effluent with high **biological oxygen demand (BOD)** and high-suspended solids content.[6] This reduces the **dissolved oxygen (DO)** levels meaning less oxygen is available to fish and other aquatic organisms. Trace elements of pesticides also remain in the wastewater. Some of these detergents used for scouring are banned in Europe, but not elsewhere.[7]

Shrink proofing

Anti-shrinking treatments prevent wool from felting during wash and generally include chlorine in some form. Chlorine-Hercosset is a treatment used on wool fibre. Dry chlorination is a treatment carried out on wool fabric using chlorine gas. Repeat exposure to chlorine can affect the human respiratory system. In addition, depending on the amount used and how it is handled, chlorine may be released into the air and water and in certain conditions may form dioxins.[8] The wastewater from the wool chlorination process contains chemicals of environmental concern. Due to these chemicals, this wastewater cannot be accepted by water treatment facilities in the United States. Therefore all chlorinated wool is processed in other countries, and then imported.[9]

DYEING

The dyeing processes for wool involves standard industry chemicals and water use. Certain types of dyes are suspected carcinogens and mutagens, and untreated dye water can negatively impact receiving water bodies and harm aquatic ecosystems if left untreated before its release.

MORE INFO PART 5: DYEING & PRINTING

CONSUMER CARE/WASHING

Woven wool fabrics may be handwashed, spot cleaned, or dry-cleaned, depending on the product. Washing and caring for any product can cause significant environmental impacts due to chemicals used in cleaning products. Certain chemicals used in dry-cleaning and at-home products have been reported to have detrimental effects on humans and the environment, contribute to ozone depletion and can pollute wastewater.

MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

Although 100% wool fibre is biodegradable, the amount of time it could take for a wool product to decompose naturally and in a short period of time is dependent upon a number of conditions—including how much air, temperature and sunlight the fibre is exposed to. If the waste is buried in a landfill, it can take even longer for it to break down.[10]

MORE INFO APPENDIX: BIODEGRADABILITY

OPTIMIZE SUSTAINABILITY BENEFITS

OPPORTUNITY	BENEFITS	CONSIDERATIONS
Promote suppliers using certified organic Merino wool.	No disallowed chemicals used. Organic feed fed to animals. Carrying capacity of the grazing land is considered and the size of the flock is monitored to avoid land degradation. Animals are quarantined when sick, rather than continuously fed with antibiotics.	Organic wool is available, though not so readily as conventional. Organic wool is more expensive than conventional wool.
Promote suppliers who use natural substances to scour wool tops.	Provides "gentle" scour, which results in less biological load and fewer toxic chemicals in the wastewater	
Implement humane methods of flystrike control in Merino sheep.	Sheep are treated holistically as a first resort if flystrike occurs.	Methods of mulesing and chemical application are used only when absolutely necessary. Less available than conventional wool.
Promote the use of chlorine-free wool.	Chlorine is not used during the shrink proofing process.	
Promote suppliers who treat the effluent after the scouring process, and reclaim the lanolin.		

OPTIMIZE SUSTAINABILITY BENEFITS

OPPORTUNITY	BENEFITS	CONSIDERATIONS
Promote suppliers who use recycled Merino wool.	Available in Northern England and Prato, Italy. Since wool is a renewable resource, the primary benefit of recycled wool is in reducing loads on landfill. However, using recycled wool may also ease the pressure that industrialized sheep ranching places on the land.	Recycling wool creates shorter fibres, which need to be blended with a percentage of virgin wool or synthetic fibre to maintain strength for finer-count yarns. The coarser the yarn count, the less virgin wool or synthetic fibre is required.
Promote suppliers using Cardato Regenerated CO2 Neutral products.[11]	The Cardato Regenerated CO2 Neutral brand certifies both the carbon footprint of the textile production process and the use of regenerated raw materials. To carry the label, products must be produced in Prato; produced with at least 70% of recycled material (recycled clothing or textile off-cuts); and be made by mills that have accounted for their CO2 emissions and have purchased emission credits from the Prato Chamber of Commerce.	
Promote the use of natural colour wool.	No bleaches or dyes are used in this case, and associated pollution impacts are avoided.	
Promote wildlife-friendly grazing practices for Cashmere goats. **Prioritize sites that have endangered wild species.**	Decreases impacts of overgrazing and loss of biodiversity due to desertification.	
Develop relationships with producers and monitor farmers.	Ensures animal-friendly practices are being implemented.	
Promote OEKO-TEK certified wool.[12]	Ensures that products pose no risk to health. These products do not contain allergenic dye-stuffs and dye-stuffs that form carcinogenic aryl-amines, and several other banned chemicals. The certification process includes thorough testing for a long list of chemicals	

AVAILABILITY

There are several companies supplying organic wool fabrics and yarns internationally.

Recycled wools are readily available in West Yorkshire, UK, and Prato, Italy.

Non-mulesed wool is available in Patagonia, South America, and even in certain areas of Australia, since the blowfly does not exist in these areas.

END USE

The applications for wool vary according to the type of fibre/breed of sheep and animal.

Organic certification is now available for a variety of wool types and certified organic wool fabrics range from fine knit wool crepes to woven melton.

Recycled wool lends itself more to knit sweaters and coarser fabrics, though smaller percentages of recycled wool are found in high-end tweed fabrics made by Italian mills.

MARKETING OPPORTUNITIES

certified organic wool With certification from an internationally recognized agency accredited by IFOAM.

X% post-consumer recycled wool

X% post-industrial recycled wool

biodegradable All fibres, yarns, trims and dyes used to manufacture the product or garment must also be biodegradable, or disassembled before disposal. This should be substantiated with documentation that the product can completely break down into non-toxic material by being processed in a facility where compost is accepted. Secondary label or marketing material should be provided to instruct customer.

PROMOTE SUPPLIERS WHO USE CHLORINE-FREE WOOL.

Patagonia chlorine-free Merino wool shirt.

Source: Patagonia.com

INNOVATION OPPORTUNITIES

1. Use organic wool in blends to add character and texture to organic cotton.

2. Use naturally coloured wool (black/brown) to create heathers with white wool or cotton.

3. Implement an integrated approach to flystrike prevention. Work with ranchers to combat flystrike through holistic means, and use mulesing and chemical applications as a last resort.

4. Consider using a coloured wool wrap around a less expensive cotton core to create a marled yarn.

5. Combine stripes of organic wool with stripes of organic cotton and agitate in hot water to felt the wool and pucker the cotton.

6. Use wool in strategic areas of a garment to emphasize its self-cleaning and moisture absorbent attributes, such as under the arms.

7. Partner with a local cleaner to promote wet or steam cleaning to the customer instead of dry-cleaning.

8. Work with Australian Wool Innovation Limited (AWI) or e-wool to obtain a list of Australian Merino ranchers that have incorporated methods to replace mulesing:
   wool.com
   e-wool.com.au

9. Work directly with producers of cashmere goats to strategize wildlife-friendly grazing practices and to ensure animal friendly practices are being implemented.

10. Instead of boycotting, work directly with producers of Merino and angora wool to request the implementation of animal- friendly practices.

11. Know who your fibre or product is being sourced from. Be aware that when there is high demand for a fibre—a fibre that typically gets produced in poor countries with little or unenforced regulations for workers and animals—the likelihood of animal cruelty and poor worker conditions increases.

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3. ah.novartis.com.au/livestock_products/clik.html/section/470
4. www.cnn.com/2010/WORLD/asiapcf/09/12/mongolia.cashmere.herders/
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6. www.polyseed.com/misc/BODforwebsite.pdf
7. oecotextiles.wordpress.com/2009/08/11/what-does-organic-wool-mean/
8. www.epa.gov/chemfact/f_chlori.txt
9. www.patagonia.com/us/patagonia.go?assetid=8516
10. www.greenlivingtips.com/articles/waste-decomposition-rates.html
11. www.nicefashion.org/en/professional-guide/recycling/Recycledtextiles.html
12. www.OEKO-TEK.com/media/downloads/Factsheet_OETS_100_EN.pdf

MANUFACTURED FIBRES

Manufactured fibres are divided into three main classifications: cellulosic, protein (azlon) and man-made synthetic fibres.

Manufactured cellulosic fibres account for approximately 8% of global man-made fibres. These fibres are derived from a range of plant-based and woody materials, which require intensive chemical manufacturing processes to be transformed first into pulp and then into "regenerated" cellulosic filaments. These fibres include modal, lyocell, viscose made from bamboo and viscose made from wood.

Protein fibre, otherwise known as Azlon, is fibre which is composed of regenerated, naturally occurring protein derived from a number of sources, including: soybean, peanut, casein (from milk), zein (from maize), and collagen/gelatin (from animal protein) to name a few. Protein fibres have received considerable attention in the United States, Europe, China and Japan as an inexpensive substitute for wool, silk and cashmere fibres.

Man-made synthetic fibres are created using a polymerization process combining many small molecules into a large molecule (a polymer). Many of the polymers that constitute man-made fibres are similar to compounds that make up plastics, rubbers, adhesives and surface coatings. Examples of man-made synthetic fibres include acrylic, elastane, nylon, and polyester.

ACRYLIC

The environmental impacts of acrylic greatly outweigh its benefits. This lack of balance indicates the necessity of exploring more sustainable options—from using other fibres entirely, to working with partners to develop recycling capabilities for acrylic.

MANUFACTURED FIBRE

Recent reports have indicated that acrylic is gradually decreasing in usage, but it still represents a large portion of overall synthetic fibre use. In 2010, world production of acrylic fibres was at 1 billion tonnes, most of which is produced in China and Europe.[1] 567,000 tonnes of acrylic fibre was produced in Europe in 2012.[2]

BENEFITS

Acrylic is a man-made synthetic fibre in which the fibre-forming substance is any long-chain synthetic polymer.[3] Acrylic production is a multi-step chemical process that is produced from 85% acrylonitrile. Acrylonitrile is made through a chemical process from propylene gas.[4] Propylene is a gas that is produced from the byproduct of refinery operations.[5]

Acrylic is reasonably comfortable and has a wool-like aesthetic, and is less expensive than wool. Due to its durability, and excellent sunlight and general wearability resistance, acrylic fabrics have the potential to last and be worn many times, optimizing the energy and resources embodied in the garment.

Acrylic is machine washable, and acrylic products are generally washed in cold water and drip-dried, thereby minimizing water and energy use associated with consumer care and washing.

AIR EMISSIONS FROM THE ACRYLIC PROCESS INCLUDE VOLATILIZED RESIDUAL MONOMER, ORGANIC SOLVENTS, ADDITIVES, AND OTHER ORGANIC COMPOUNDS.

POTENTIAL IMPACTS

PROCESSING

Acrylic fibres contain at least 85% acrylonitrile. Studies done by the **United States Environmental Protection Agency (EPA)** show that workers repeatedly breathing small amounts of acrylonitrile over long periods of time may develop cancer. Acrylonitrile enters the body through inhalation or absorption through skin contact.[6] The Centers for Disease Control and Prevention (CDC) suggest preventing skin contact.[7]

Acrylic processing emits high amounts of **Volatile Organic Compounds (VOCs)**. Air emissions from the acrylic process include volatilized residual monomer, organic solvents, additives, and other organic compounds used in fibre processing.[8]

POTENTIAL IMPACTS cont'd

DYEING AND FINISHING

Certain types of dyes are suspected carcinogens and mutagens, while other dyes are known to have a sensitizing effect on skin and should be avoided. Untreated dye water can negatively impact receiving water bodies and harm aquatic ecosystems if left untreated before its release.

MORE INFO PART 5: DYEING & PRINTING

Anti-pilling treatments

Acrylic fibres are highly likely to pill. Some fabrics are chemically treated during the manufacturing process in order to reduce their propensity to pill.

CONSUMER CARE/WASHING

Acrylic is typically machine-washed. Certain at-home products have been reported to have detrimental effects on humans and the environment and contribute to ozone depletion and can pollute wastewater.

MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

Acrylic has durability to last the wearer several years; however, it is typically used in inexpensive, **fast-fashion** garments that are worn and quickly discarded. Synthetic fibres are from a carbon-based chemical feedstock and are considered **non-biodegradable**. [9]

There is no sufficient data supporting how long it takes acrylic fabric to **decompose** in landfills. Comparing acrylic degradability to polyester **degradability** could be sufficient, since they are both synthetic polymers originating from oil. There are, however, conflicting opinions about how long polyester takes to decompose and estimates range from 40 years to 1000 years. This is because degradability is dependent upon a number of conditions including how much air, temperature and sunlight the fibre is exposed to.

MORE INFO APPENDIX: WASTE-TO-ENERGY

OPTIMIZE SUSTAINABILITY BENEFITS

OEKO-TEK certified acrylic[10]

OEKO-TEK is an independent, third party certifier that offers two certifications for textiles: OEKO-TEK 100 (for products) and OEKO-TEK 1000 (for production sites/factories). OEKO-TEK 100 label aims to ensure that products pose no risk to health. OEKO-TEK certified products do not contain allergenic dye-stuffs and dye-stuffs that form carcinogenic aryl-amines. The certification process includes thorough testing for a long list of chemicals. Specifically banned are: AZO dyes, carcinogenic and allergy-inducing dyes, pesticides, chlorinated phenols, extractable heavy metals, emissions of volatile components, and more.

AVAILABILITY

Most of the global acrylic fibre capacity is in Asia, with a concentration in China. North America and West Europe together now account for less than 20% of global capacity. [11]

OEKO-TEK certified acrylic is available in China.

APPLICATIONS

Sweaters, women's and children's apparel, sportswear, socks, knitted underwear, pajamas, gloves, carpets, rugs, upholstery, cushions, blankets, outdoor umbrellas, tents.

MARKETING OPPORTUNITIES

OEKO-TEK® Standard 100 certified If verified and used.

INNOVATION OPPORTUNITIES

1. Shift to existing environmentally beneficial fabrics when possible. These fabrics include fabric derived from organic wool, recycled fabrics and **TENCEL**.®

2. Recycled fibres, such as cotton, wool and polyester, lose strength when they are shredded. Use acrylic with different blends of recycled fibres to strengthen the yarn and promote durability.

3. Investigate alternative technologies for colouring acrylic fabrics, such as transfer printing, which eliminates water from the dyeing process.

4. Design garments and products with reusable elements—such as trims and tags. Design the product so that trims and tags can be easily separated from the main body of the product at the end of its useful life to enable easy recycling. Create collection systems for the products. Collect, disassemble, reuse.

5. Create internal store collections of acrylic garments and products. Use fabric from collected garments and products to innovatively redesign new products.

6. Work with partners to develop closed loop recycling of acrylic fibres and infrastructure to label, collect, sort and purify garments.

7. Get your product Cradle to Cradle Certified. The Cradle to Cradle Certified™ Product Standard is a multi-attribute, continuous improvement methodology that provides a path to manufacturing healthy and sustainable products. The Standard rewards achievement in five categories and at five levels of certification. An accredited assessor will help to assess and optimize your product.

8. Create garments that emphasize natural pilling of acrylic in order to increase lifespan of product, and divert waste from landfills.

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2. www.cirfs.org/KeyStatistics/AcrylicinEurope.aspx
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7. www.cdc.gov/niosh/npg/npgd0014.html
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11. www.yarnsandfibres.com/preferredsupplier/spreports_fullstory.php?id=527

ELASTANE

The manufacturing process of elastane is highly chemical and is derived from petroleum, a non-renewable resource. Elastane is non-biodegradable, and will impede the biodegradability of any natural fibre it is blended with. Efforts to address sustainability in these areas could help the overall positive influence of elastane on the environment.

MANUFACTURED FIBRE

Elastane—also known as spandex—is the generic name for the synthetic, manufactured fibre whose fibre-forming substance is a long chain synthetic polymer. It comprises of at least 85% of segmented polyurethane. Some trade names for these fibres include LYCRA® (DuPont) and DORLOSTAN® (Bayer).[1]

When used as the central filament core yarn with staple fibres such as cotton, elastane becomes the silent hero in the consumer use stage as it can prolong the life of a product by helping it retain its shape.

BENEFITS

Elastane was developed as an alternative to traditional natural fibres, since it can stretch and snap back to its original form, whereas natural fibres cannot.

The environmental benefits of elastane occur in the consumer use phase. Elastane can be stretched repeatedly—up to 500% of its length—and will return back to its original size. It is lightweight, soft, smooth and does not restrict movement. It can be easily dyed and is resistant to abrasion, body oils and perspiration.

What makes elastane special is its compatibility with other fibres or yarns. Elastane fibres are included in textile applications where high elastic extension and recovery are needed for the material produced—such as stretch denim, activewear and underwear.[2] This allows for less stress on seams, and helps prevent garments from becoming loose-fitting in high stress areas such as the elbows or knees. This feature about elastane can assist with prolonging the life of the product and diverting waste from landfills.[3] When used as the central filament core yarn with staple fibres such as cotton, elastane becomes the silent hero in the consumer use stage as it can prolong the life of a product by helping it retain its shape.

Elastane can be machine washable and drip-dried, depending on the other fibres it is combined with, thereby minimizing water and energy use associated with consumer care and washing.

ELASTANE FIBRES ARE INCLUDED IN TEXTILE APPLICATIONS WHERE HIGH ELASTIC EXTENSION AND RECOVERY ARE NEEDED, SUCH AS STRETCH DENIM.[2]

POTENTIAL IMPACTS

PROCESSING

All elastane fibres are segmented polyurethane and formed through spinnerets either by melt extrusion or by solvent spinning.[4] Polyurethane is a byproduct of petroleum, which is a non-renewable resource. Petroleum takes millions of years to form, and is currently being extracted from the earth for industrial uses faster than it can be replenished. The declining petroleum supply is the source of much debate—British Petroleum (BP) reports that there are 1,333 billion barrels still available to pump (enough for 40 years at current usage rates).[5] Other sources state that supply is overestimated and that reserves are about 30% lower than widely reported.

Many common solvents used for elastane production are toxic. Solvents such as dimethylformamide (DMF) are a potent liver toxin and research points to a possible association with cancer.[7]

The production of elastane emits hazardous pollutants to air, which include: toluene and 2,4-toluene diisocyanate (TDI).[8] Toluene is found in gasoline, acrylic paints, varnishes, lacquers, paint thinners, adhesives, glues, rubber cement, airplane glue and shoe polish. Although not characterized as a carcinogen, chronic inhalation exposure to toluene and 2,4-toluene diisocyanate in workers has caused significant decreases in lung function, and an asthma-like reaction.[9] Toluene levels of 500 ppm are considered immediately dangerous to life and health.[10]

DYEING AND FINISHING

Certain types of dyes are suspected carcinogens and mutagens, while other dyes are known to have a sensitizing effect on skin and should be avoided. Untreated dye water can negatively impact receiving water bodies and harm aquatic ecosystems if left untreated before its release.

MORE INFO PART 5: DYEING & PRINTING

END OF USE

Elastane is used in a variety of different garments at different price points. It has durability to last the wearer several years; however, it is often used in inexpensive, **fast-fashion** garments that are worn and quickly discarded. Synthetic fibres are from a petroleum-based feedstock and are considered **non-biodegradable**.[11]

Since elastane is often combined with biodegradable natural fibres, it can greatly influence the biodegradability of these fibres. For example, if even only 2% of elastane is combined with 98% cotton, it can cause the garment to be non-biodegradable.

MORE INFO APPENDIX: WASTE-TO-ENERGY

OPTIMIZE SUSTAINABILITY BENEFITS

OEKO-TEK CERTIFIED ELASTANE

OEKO-TEK is an independent, third party certifier that offers two certifications for textiles: OEKO-TEK 100 (for products) and OEKO-TEK 1000 (for production sites/factories). OEKO-TEK 100 label aims to ensure that products pose no risk to health. OEKO-TEK certified products do not contain allergenic dye-stuffs and dye-stuffs that form carcinogenic aryl-amines. The certification process includes thorough testing for a long list of chemicals. Specifically banned are: AZO dyes, carcinogenic and allergy-inducing dyes, pesticides, chlorinated phenols, extractable heavy metals, emissions of volatile components, and more.[12]

BIO-BASED ELASTANE

Genomatica, a process technology developer for the chemical industry located in the United States, has developed a process that converts sugar (derived from sugar cane, beets or others) into commercial grade 1,4-butanediol (BDO), known as the GENO BDO™ process. BDO is a precursor to the chemical that makes elastane fibres. Bio-based BDO produced from the GENO BDO™ process is made from renewable feedstocks, rather than a conventional BDO made with petroleum-based feedstocks. Genomatica is currently licensing their process technology to producers and users in the chemical industry.[13]

AVAILABILITY

OEKO-TEK® Standard 100 certified elastane is available. Manufacturers can be found at:
www.OEKO-TEK.com/en/manufacturers/certified_products/certified_products.html

Bio-based elastane is available by contacting Genomatica to be connected with suppliers that license the GENO BDO™ process.

APPLICATIONS

Covered elastic yarn (covered with a spun or filament yarn to hide the elastane yarn): Heavyweight foundations, elastic bandages, althetic supporters.[3]

Bare elastic yarn (monofilament elastane fibre): Swimwear, athletic wear, lightweight foundation garments.[3]

Core spun yarns (central filament core with staple fibre): active sportswear, stretch denim, stretch chino.[3]

MARKETING OPPORTUNITIES

OEKO-TEK® Standard 100 certified If verified and used.

XX% bio-based If verified and used.

INNOVATION OPPORTUNITIES

1. Investigate alternative technologies for colouring synthetic fabrics, such as transfer printing, which eliminates water from the dyeing process.[14]

2. Design garments and products with reusable elements—such as trims and tags. Design the product so that trims and tags can be easily separated from the main body of the product at the end of its useful life, to enable easy recycling. Create collection systems for the products. Collect, disassemble, reuse.

3. Work with partners to develop closed loop recycling of elastane/natural fibres and infrastructure to label, collect, sort and purify garments.

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2. www.nepis.epa.gov
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IMITATION LEATHER

There are several types of alternatives to genuine leather. The more popular materials, including thermoplastic polyurethane (TPU), polyurethane laminate (PUL) and polyvinyl chloride (PVC), are often used for jackets, handbags, shoes and upholstery, and were developed as inexpensive alternatives to leather. These materials are man-made synthetic products.[1]

MANUFACTURED FIBRE

BENEFITS AND POTENTIAL IMPACTS

	DESCRIPTIONS	BENEFITS	IMPACTS
Thermoplastic polyurethane (TPU)	Heat bonding lamination process where no solvents are necessary. Two types of TPU are common: polyester based and polyether based.	• Can be waterproof and weigh less than genuine leather. • Can be constantly reused, which is why it's often used for disposable diapers. • Could be considered "animal friendly" since it is not derived from the hide of a cow. • These products have the visual aesthetics of genuine leather, but at substantially less cost.	• Less durable than genuine leather. • The base material used to form polyurethane compounds is a by-product of the oil refining process. • Almost all commercial grade polyurethanes available are based on two different isocyanates: TDI (toluene diisocyanate) and MDI (methylene bisdiphenyl diisocyanate). • TDI is considered a **volatile organic compound (VOC)** and has acute and chronic effects on humans.[2] • Not biodegradable. • Not recyclable.
Polyurethane laminate (PUL)	A polyurethane coating is laminated onto fabrics such as polyester or cotton, and uses solvents in a chemical bonding process.	• Durable, waterproof, flexible. • Can be constantly reused. • These products have the visual aesthetics of genuine leather, but at substantially less cost. • Could be considered "animal friendly" since it is not derived from the hide of a cow.	Impacts are the same as TPU above.
Polyvinyl chloride (PVC)		• Polyvinyl chloride (PVC) is a versatile plastic that can take on a variety of characteristics—rigid, filmy, flexible and leathery—with relatively limitless applications. • • Could be considered "animal friendly" since it is not derived from the hide of a cow. • • These products have the visual aesthetics of genuine leather, but at substantially less cost.	• Less durable than genuine leather. • Dioxin (the most potent carcinogen known), ethylene dichloride and vinyl chloride are emitted during the production of PVC and can cause acute and chronic health problems, including cancer, endocrine disruption, and reproductive and immune system damage.[2,3] • Chemical stabilizers are necessary in the creation of PVC, including **lead**, **cadmium** and **organotins**. Phthalates are used to soften PVC. Certain phthalates have been banned in the European Union, such as DEHP, BBP and DBP, and are known to cause acute and chronic health problems, and are possible carcinogens.[4, 5] • During use, dioxins and phthalates can leach, flake or outgas from PVC over time, again emitting dioxin and heavy metals into the air, water and land. • Fibre is less breathable than polyurethane. • Not biodegradable.

OTHER SUBSTITUTES TO GENUINE LEATHER

PU SPLIT LEATHER

PU split leather, also known as "PU split," comes from the same hide as 100% genuine leather. The hide is prepared and tanned. Since the hide is too thick to use on its own, it is split into layers: the top layer is of the highest quality, and is considered pure leather. The lower layer, called "split," is also considered 100% genuine leather and looks like suede. For the processing of PU split leather, the tanner applies a thin layer of polyurethane (PU) with foil or extrusion that hardens on top. A hair cell pattern can be embossed on the PU layer so that it looks like genuine leather. PU coated split leather is not considered 100% leather.

BONDED LEATHER

Bonded leather also comes from the same hide as 100% genuine leather. The hide is prepared and tanned. Small pieces of leather that are cut away from the final usable piece are combined with composite materials and spread out in sheets. Foil is put on top to resemble the top layer of leather. Bonded leather is to 100% genuine leather as particle board is to wood. Bonded leather is not considered 100% leather.

OPTIMIZE SUSTAINABILITY BENEFITS

- Promote suppliers who use alternatives to PVC.
- Promote suppliers who use water-based solvents for Polyurethane laminate (PUL).
- Investigate "vegan leathers" made out of polyester or polyamide microfibre, which could allow them to be recyclable.
- Consider using 100% genuine leather that utilizes low-chrome tanning, non-chrome tanning or vegetable tanning processes.

AVAILABILITY

Vegetable, low- or -no-chrome tanned leather is readily available.

Water-based solvents for PUL are currently being researched.

Microfibre made out of synthetics, such as polyester, are readily available.

APPLICATIONS

Chrome tanning still provides the softest quality leather most suitable for high end clothing.

Vegetable tanned leather is applicable to bags, belts and some shoes.

Bonded leather is applicable for belts, shoe soles and furniture upholstery, though it could be creatively applied to bags.

Microfibre for leather substitutes made out of polyester is applicable for shoes, handbags and upholstery.

Microfibres for leather substitutes made out of 100% chemically recycled polyester is available through Toray in the United States. [7]

MARKETING OPPORTUNITIES

vegetable tanned leather or "naturally tanned" leather If vegetable or naturally tanned.

post-consumer recycled leather If from used garments.

100% recyclable If polyester or polyamide microfibre is used, and infrastructure to collect products and garments is in place.

NOTE: Simply saying "vegan leather" is not enough to substantiate sustainability claims, since these processes are generally derived from petroleum and can be toxic.

INNOVATION OPPORTUNITIES

1. At the product design stage, consider what will happen to imitation leather products at the End of Use stage of the lifecycle. Design products that address longevity, recyclability, biodegradability, disassembly for reuse, etc.

2. Explore innovative imitation leather fabrications that specifically address toxicity during production and use.

3. Work with partners to develop closed loop recycling of imitation leather products.

4. Design completely recyclable products where all materials and component parts recycle fully and safely. Partner with textile recycling facilities to guarantee effectiveness of recycling ability. Set up infrastructure to collect products. Communicate the proper route of disposal to consumers through POS and hangtags.

5. Use recycled leather collected from tanneries to create modular accessories or patchwork pieces; or use in trims on garments.

100% POLYESTER MICROFIBRE SUEDE BOOTS MADE BY GOOD GUYS.

Source: www.goodguys.fr

1. www.advleather.com/bicast.html
2. www.mnn.com/family/family-activities/blogs/eu-bans-toxic-phthalates-and-other-chemicals
3. www.healthychild.org/easy-steps/avoid-phthalates-find-phthalate-free-products-instead%E2%80%A8%E2%80%A8/
4. www.www.mnn.com/family/family-activities/blogs/eu-bans-toxic-phthalates-and-other-chemicals
5. www.healthychild.org/easy-steps/avoid-phthalates-find-phthalate-free-products-instead%E2%80%A8%E2%80%A8/
6. www.healthybuilding.net/pvc/facts.html
7. www.ultrasuede.com/about/responsibly_engineered.html

LYOCELL

Lyocell fibre is made from cellulose originating from eucalyptus wood and it has unique material properties that can be suitable for a variety of different applications. The manufacturing process for lyocell is a closed loop process, which makes it a viable sustainable alternative to cotton, viscose and possibly other synthetics.

MANUFACTURED FIBRE

BENEFITS

Eucalyptus trees, from which lyocell is derived, grow rapidly on marginal lands without artificial irrigation, gene manipulation or synthetic pesticides.

Lyocell has a smooth fibre surface and round cross section. This fibrillar structure enables improved dye pickup and achieves vibrant colours and a slight sheen on the surface of the fabric while using less dye-stuff and less water throughout the dyeing process.

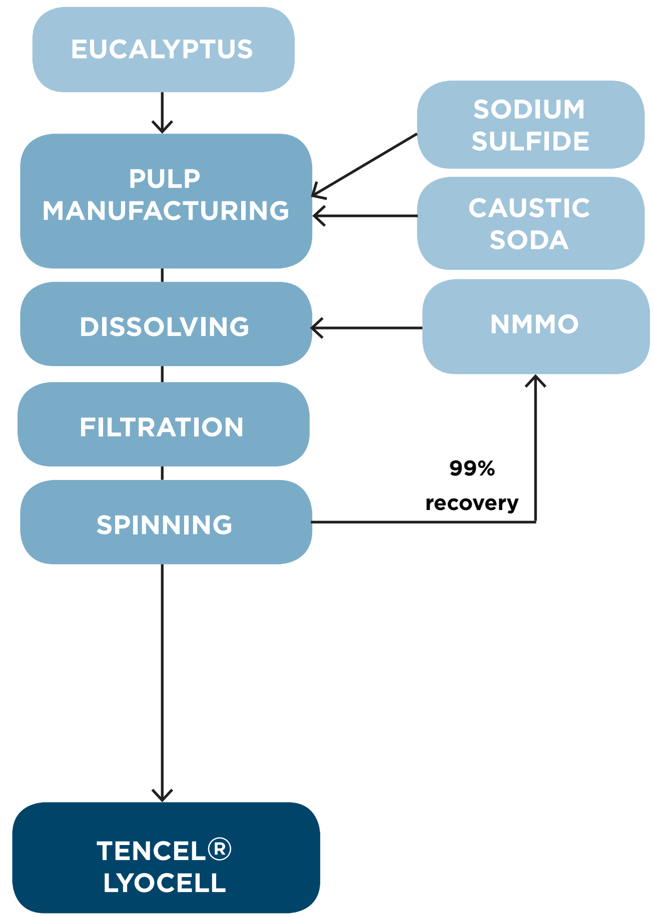
In all applications, lyocell has moisture wicking properties, good absorbency, is wrinkle resistant and has good drapability.

To transform hard wood into lyocell fabric, the cellulose must be separated from other compounds found in the trees. The wood material is dissolved through an intensive chemical processes into a pulp, which is then extruded to form fibres. The solvent used to transform the pulp into fibre is amine oxide (NMMO=N-Methyl-Morpholine-N-Oxide), which is considered non-toxic.

TENCEL® lyocell is the registered brand name for lyocell fibres manufactured by Lenzing in Austria. The TENCEL® lyocell fibre manufacturing process operates as a closed loop system, in which 99.8% of the solvent is recovered, filtered and reused and any remaining emissions are broken down harmlessly in biological wastewater treatment plants.[1, 2, 3]

Lenzing also claims that the trees used as feedstock for TENCEL® lyocell are harvested from sustainably managed farms certified by the **Forest Stewardship Council (FSC)** or **Programme for the Endorsement of Forest Certification (PEFC)**.[4] Lenzing has also confirmed that pulp used for the manufacture of TENCEL® lyocell fibre is supplied from production locations that comply with the EU Timber Regulation.[4, 5]

TENCEL® LYOCELL® MANUFACTURING PROCESS



BENEFITS cont'd

Since lyocell fibre absorbs and redirects moisture (i.e., sweat) fewer washings may be needed, resulting in water and energy savings as well as reduced wear and tear that occurs with repeated laundering.

The dyeing process for lyocell can significantly reduce water consumption and dye and chemical use due to its good colour absorption.

Depending on the dyes and trims used, lyocell may be **biodegradable** if disposed of in optimum environmental conditions (exposure to water, air, light).[4] Lenzing has reported in a Biodegradability Technical Bulletin that TENCEL® lyocell fibres were found to have degraded completely after 6 weeks when composted.[6]

POTENTIAL IMPACTS

Currently, the solvents used for lyocell are derived from petrochemicals. However, the solvents are being recovered and reused.

DYEING

Although the dyeing process for lyocell can significantly reduce water consumption and dye and chemical use due to its good colour absorption, the dyeing process still involves standard industry chemicals and water use.

MORE INFO PART 5: DYEING & PRINTING

OPTIMIZE SUSTAINABILITY BENEFITS

- Ensure that lyocell fabric is TENCEL® lyocell from Lenzing since this company discloses its raw material source, which is verified as coming from certified sustainably harvested forests.
- Cross check with Lenzing that the fabric supplier is one of their supply chain partners.
- Ask for Lenzing "certification" on the fabric—this is readily available if TENCEL® lyocell content is 30% or above.

100% TENCEL® LYOCELL BED SHEETS

Image source: www.downlitebedding.com

AVAILABILITY

Most lyocell made is TENCEL® lyocell. TENCEL® lyocell is readily available and the fibre is produced in three production sites: Mobile, Alabama, USA; Grimsby, United Kingdom; and Heiligenkreuz, Burgenland, Austria.

END USE

Suitable product applications for lyocell depend on the fabric weight and construction, and include denim, dress pants, jackets, dress shirts, blouses, active wear, sleepwear, work wear, and home textiles in woven and knit applications.

MARKETING OPPORTUNITIES

TENCEL® lyocell Fabric should be referred to as TENCEL® lyocell.

low impact fibre Since lyocell is derived from a natural renewable resource, and developed using a closed loop process it is considered a low impact fibre, and can be safely labeled as such.

FSC-certified If TENCEL® lyocell from FSC or PEFC-certified plantations is used, this can be claimed.

PEFC-certified If TENCEL® lyocell from FSC or PEFC-certified plantations is used, this can be claimed.

biodegradable All fibres, yarns, trims and dyes used to manufacture the product or garment must also be biodegradable, or disassembled before disposal. This should be substantiated with documentation that the product can completely break down into non-toxic material by being processed in a facility where compost is accepted. Secondary label or marketing material should be provided to instruct customer.

INNOVATION OPPORTUNITIES

1. Design garments with lyocell used in high-perspiration areas of the garment, such as the underarm, to take advantage of its moisture absorbing and wicking properties.

2. Explore innovative fabrications that use blends with lyocell (with organic cotton/recycled cotton, for example).

3. Use tags and hangtags to encourage consumers to wash cotton garments in cold water, and tumble dry and iron only when necessary.

4. Design completely biodegradable garments where all fibres and component parts compost fully and safely. Partner with composting facilities to guarantee effectiveness of composting ability. Communicate with customers the proper disposal through POS and hangtags.

5. Create a lyocell/cotton blended jean. Blend at least 25% lyocell with cotton to improve washing processes, and reduce water and chemical use.

6. Design garments and products with reusable (synthetic) trims, and a biodegradable body. Design the product so that non-biodegradable trims, tags, buttons, etc., can be easily separated from the main body of the product at the end of its useful life. Create collection systems for the products. Collect products and separate trims from biodegradable lyocell body. Distribute lyocell to compost facility, and reuse trims.

1. Textile Exchange "TENCEL® lyocell From Lenzing" March 2011
2. www.lenzing.com/sites/botanicprinciples/website/index.htm
3. symposium.lenzing.com/fileadmin/template/pdf/lectures_speakersLCA_Li_shen.pdf
4. Dr. Bianca SCHACHTNER, personal communication, January 14, 2014.
5. ec.europa.eu/environment/forests/timber_regulation.htm
6. www.spuntech.com/files/sertificates/Biodegradability.pdf

OTHER: www.lenzing.com/en/fibres/TENCEL® lyocell/TENCEL® lyocellr.html

MODAL

The material properties for modal material properties are similar to traditional viscose, however it has three major differentiating characteristics: the manufacturing process for Modal is less toxic and it has greater wet strength, which means that Modal is machine washable.

MANUFACTURED FIBRE

Modal is categorized as a “manufactured” or “man-made” fibre created from cellulose originating from beech trees. It is then chemically processed and regenerated to form a new polymer using the viscose process.

BENEFITS

Beech trees are soil enhancers, breed naturally and do not need artificial irrigation. The beech tree is naturally resistant to pests and disease.[1]

Modal’s distinguishing fibre characteristics are its extra softness and high wet strength. Modal is machine washable, and can be washed in cold water and drip-dried, thereby minimizing water and energy use associated with consumer care and washing. Modal fibres do not shrink or get pulled out of shape when wet, like viscose.[2]

Modal drapes well, is easy to dye, and is highly absorbent.

Lenzing Modal® is the registered brand name for the second generation of viscose fibres manufactured by Lenzing in Austria. The fibre is harvested from beech trees in PEFC (Programme for the Endorsement of Forest Certification) certified European forests.[2]

The Lenzing Modal® manufacturing process is non-toxic and operates in a system where 95% of outputs are recovered, filtered and reused.[1]

Lenzing Modal® Colour is a unique process that addresses environmental impacts from dying. Lenzing Modal® Colour adds the colour pigment directly to the fibre matrix, so dyeing is no longer necessary. Tests show when processing Lenzing Modal® Colour, up to 80% of energy and up to 76% of water can be saved in comparison to the standard fibre (in jet dyeing).[2] Lenzing Modal® Colour can achieve most colours, including black.[4]

Lenzing Modal® and Lenzing Viscose® Austria are the only man-made fibres which are **carbon neutral**.

MODAL IS MACHINE WASHABLE, AND CAN BE WASHED IN COLD WATER AND DRIP-DRIED.

POTENTIAL IMPACTS

DYEING AND FINISHING

Not all colours can be Lenzing Modal® Colour, so traditional dyeing methods might have to be used. The dyeing process for modal is a multi-step process that involves ample amounts of water at high temperatures.

MORE INFO PART 5: DYEING & PRINTING

CONSUMER CARE/WASHING

Electricity and water use in the care of the garment can cause significant environmental impacts. Certain chemicals used in at-home products have been reported to have detrimental affects on humans and the environment, contribute to ozone depletion and can pollute wastewater.

MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

Although there are several claims that Modal is biodegradable, there is no research substantiating this fact. Since Modal is chemically processed, the likelihood of biodegradability within a reasonable amount of time is minimal. If these garments end up in landfill, they are likely to remain there for decades.

MORE INFO APPENDIX: WASTE-TO-ENERGY

OPTIMIZE SUSTAINABILITY BENEFITS

- Use Lenzing Modal® since this Lenzing discloses its raw material source which is verified as coming from certified sustainably harvested forests.
- Cross check with Lenzing that the fabric supplier is one of their supply chain partners.
- Ask for Lenzing "certification" on the fabric.
- Use Lenzing Modal® Colour.
- OEKO-TEK certified[5] modal fabrics: OEKO-TEK is an independent, third party certifier that offers two certifications for textiles: OEKO-TEK 100 (for products) and OEKO-TEK 1000 (for production sites/ factories). OEKO-TEK 100 label aims to ensure that products pose no risk to health. OEKO-TEK certified products do not contain allergenic dye-stuffs and dye-stuffs that form carcinogenic aryl-amines. The certification process includes thorough testing for a long list of chemicals. Specifically banned are: AZO dyes, carcinogenic and allergy-inducing dyes, pesticides, chlorinated phenols, extractable heavy metals, emissions of volatile components, and more.

AVAILABILITY

Modal is readily available.

Lenzing Modal® is readily available and the fibre is produced in three production sites: Mobile, Alabama, USA; Grimsby, United Kingdom; and Heiligenkreuz, Burgenland, Austria.

Modal® is often blended with cotton, wool or synthetic fibres and allows easy tone-in-tone dyeing.

MODAL FIBRES ARE ESPECIALLY FAVORED FOR LOUNGEWEAR.

Sleepwear made from Modal® Jersey.

Snoa Sleepwear, www.snoasleepwear.com

APPLICATIONS

Modal fibres are especially favored for loungewear, sleepwear and undergarments. They can also be found in 100% form and blends with cotton, wool, silk and synthetic in apparel, outerwear and household furnishings.[6]

MARKETING OPPORTUNITIES

Lenzing Modal® If used and verified.

PEFC certified Must be verified, and can be claimed on POS items at retail.

OEKO-TEK® Standard 100 certified If used and verified.

INNOVATION OPPORTUNITIES

1. Encouraging handwashing in cold water on the hangtag and labeling/POS would influence the consumer to take an active role in reducing environmental impacts of modal at the consumer washing stage.

2. Explain the difference between the viscose process and the production process used for Lenzing Modal® on your website or POS materials.

3. Let the capabilities of Lenzing Modal® Colour persuade your decision-making when it comes to colour choices.

4. Explore recycling options for 100% modal as a raw material for regenerated cellulose fibre production.

1. www.euforgen.org/fileadmin/bioversity/publications/pdfs/1322_European_beech__Fagus_sylvatica_.pdf
2. www.lenzing.com/en/fibres/lenzing-modal/applications/lenzing-modal-colour.html
3. www.pefcregs.info
4. lenzinginnovation.lenzing.com/fileadmin/template/pdf/Texworld_USA_2012/16_01_2012_2_PM_Lenzing_Edelweiss.pdf
5. www.OEKO-TEK.com/media/downloads/Factsheet_OETS_100_EN.pdf
6. www.lenzing.com/en/fibres/lenzing-modal/height-of-fashion.html

Image Source: www.snoasleepwear.com

POLYAMIDE 6 AND POLYAMIDE 6,6

The manufacturing process of Polyamide 6 and 6,6 is highly chemical and is derived from petroleum, a non-renewable resource. Also, the fibre and its resulting fabric are non-biodegradable. Efforts to address sustainability in these areas could help the overall impact of polyamide on the environment.

MANUFACTURED FIBRE

Polyamide 6 and 6,6 are manufactured, man-made fibres that are formed from a chemical process using carbon, hydrogen, oxygen and nitrogen atoms. They differ in that they each begin with different polymer building blocks.[1]

BENEFITS

Polyamide 6 and Polyamide 6,6 share a lot of the same fibre characteristics. They have strong wear resistance, abrasion resistance, chemical resistance, heat resistance, are lustrous, have a high melting point, and are resilient.[1]

Polyamide 6,6 has greater resilience, a higher melting point, and lower stain permeability than polyamide 6, which makes polyamide 6,6 perfect for carpet.[2]

The most notable characteristic of both polyamide 6 and 6,6 is versatility. Although originally developed as an "artificial silk," it has been used for a vast variety of applications. Polyamide fibres are used for garments, sheer hosiery, parachute cloth, backpackers' tents, bridal veils, musical strings, rope, broom and tooth brush bristles, Velcro . . . and many other applications.[3]

Polyamide 6 and 6,6 blend well with other fibres, and their chief contributions are strength and abrasion resistance.[1]

Polyamide 6 and 6,6 are machine washable, dry quickly, need little pressing, and holds shape well since they neither shrinks nor stretches, thereby minimizing water and energy use associated with consumer care and washing.[4]

Due to their durability and abrasion resistance, some Polyamide 6 and 6,6 products have the potential to last and be worn many times, optimizing the energy and resources embodied in the product.

POTENTIAL IMPACTS

PROCESSING

Polyamide 6 and 6,6 are made from petrochemical feedstock, which is a non-renewable resource. Petroleum takes millions of years to form, and is currently being extracted from the earth for industrial uses faster than it can be replenished.

DYEING AND FINISHING

Certain types of dyes are suspected carcinogens and mutagens, while other dyes are known to have a sensitizing effect on skin and should be avoided. Untreated dye water can negatively impact receiving water bodies and harm aquatic ecosystems if left untreated before its release.

MORE INFO PART 5: DYEING & PRINTING

Durable water repellents (DWR)

Durable water repellents (DWR) are applied to polyamide 6 and 6,6 garments and products to allow for breathability and water repellency. Fluorochemicals are commonly used in these water-repellent finishes and waterproof membranes (thin films or coatings attached to the back of fabrics to prevent water from passing through). Two fluorinated compounds are of most concern, perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), since they are known to have persistent, bioaccumulative and toxicological effects on the environment. The European Union has banned PFOS and some countries in the EU have also banned PFOA.[6]

Waterproof membranes are engineered to be breathable, and are commonly derived from petroleum and made using PFOA.

MORE INFO PART 5: FINISHING

POTENTIAL IMPACTS cont'd

CONSUMER CARE AND WASHING

Polyamide products are typically machine-washed. Certain at-home detergents have been reported to have detrimental affects on humans and the environment, contribute to ozone depletion and can pollute wastewater.

MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

Synthetic fibres are from a carbon-based chemical feedstock and are considered **non-biodegradable.**[7] Polyamide 6 and 6,6 products have the durability to last many years, however if they are discarded, could sit in the landfill for decades.

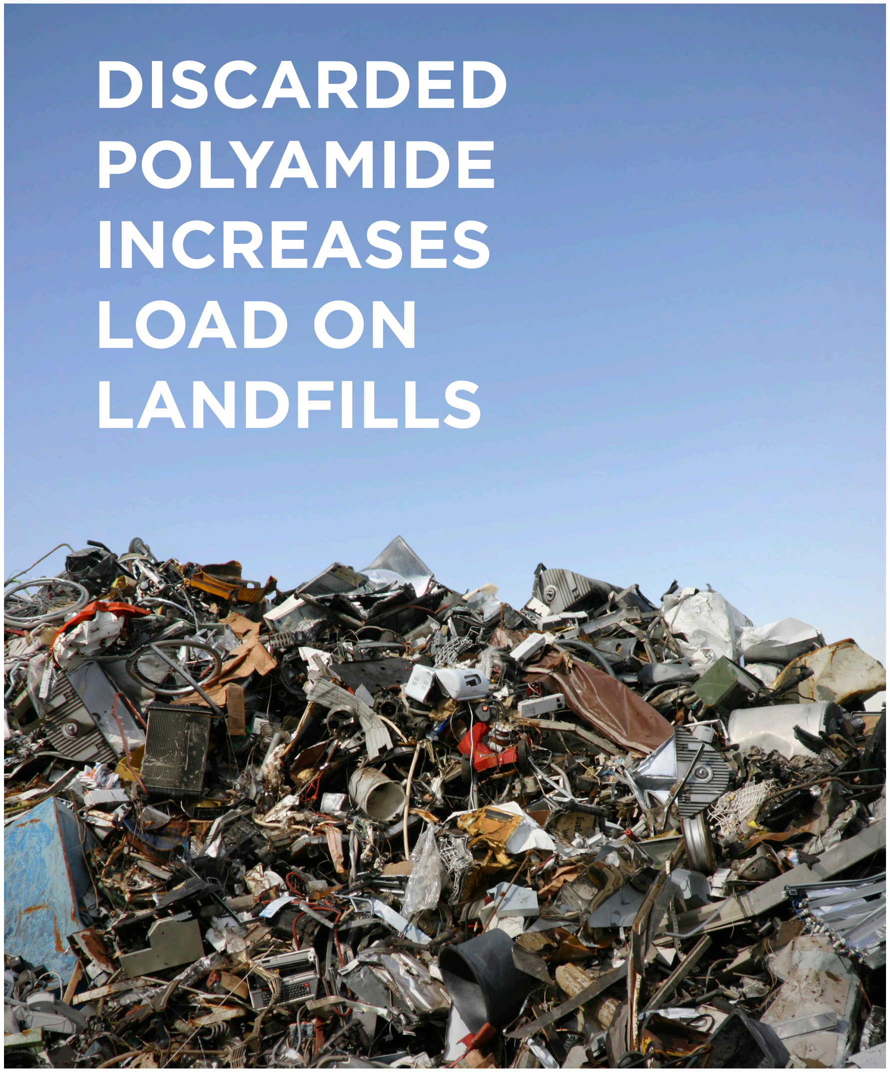
MORE INFO APPENDIX: BIODEGRADABILITY

Discarded polyamide products increase load on landfills, contribute to land and water contamination and possibly toxic emissions into the air. [8]

When incinerated, polyamide 6 and 6,6 emit chemicals, such as nitrogen oxide, formaldehyde, hydrogen cyanide and acrolein, that are poisonous and possible carcinogens.[9]

MORE INFO APPENDIX: WASTE TO ENERGY

DISCARDED POLYAMIDE PRODUCTS INCREASE LOAD ON LANDFILLS, CONTRIBUTE TO LAND AND WATER CONTAMINATION AND POSSIBLY TOXIC EMISSIONS INTO THE AIR.[8]



ALTERNATIVES TO VIRGIN POLYAMIDE

RECYCLED POLYAMIDE

Using recycled polyamide achieves two main ecological benefits: 1) it slows the depletion of virgin natural resources, and 2) it reduces textile waste building in landfills. Polyamide can be recycled into new versions of the same product or into entirely different products.

Post-consumer waste from used and discarded products and **post-industrial waste** from material collected during the product manufacturing can be recycled. There are two processes for recycling polyamide fibres: mechanical and chemical.

Mechanical recycling

Polyamide 6 and 6,6 can be effectively collected, cleaned, cut, re-melted and remolded to make yarns. However, the fibre is "**downcycled**" in this manner, which means that its physical structure breaks down, and eventually the product must be discarded to landfill.[10]

Collection, sorting and purifying discarded synthetic garments (i.e., post-consumer waste) is currently cumbersome. Infrastructures for labeling, collection and sorting need to be improved so that the post-consumer raw material source can scale to be economically viable.

Chemical recycling

There is potential for polyamide 6 to be chemically recycled. Chemical recycling involves breaking the polymer into its molecular parts and reforming the molecules into a yarn of equal strength and quality as the original, in perpetuity. In this process, the chemical building blocks are separated (depolymerization) and reassembled (repolymerization), forming what is known as a "**closed loop**" where the final stage of the product's lifecycle (disposal) forms the first stage of the next product (raw fibre). Closed loop recycled polyamide processing is currently limited to Polyamide 6, and is expensive in part because it is a relatively new technology. In addition, the infrastructure to label, collect, sort and purify discarded garments must be in place.[12]

OPTIMIZE SUSTAINABILITY BENEFITS

- Promote the use of chemically recycled, closed loop Polyamide 6.
- Support developments of chemically recycled Polyamide 6,6.
- Investigate developments in bio-polyamide 6, which use amino acids derived from dextrose fermentation as the starting material, instead of petroleum.[13]
- Investigate non-toxic flame retardant applications for polyamide.
- Promote the use of halogen-free flame retardants.
- Investigate non-toxic waterproofing methods for polyamide.
- Promote OEKO-TEK certified polyamide.[14]
  OEKO-TEK is an independent, third party certifier that offers two certifications for textiles: OEKO-TEK 100 (for products) and OEKO-TEK 1000 (for production sites/factories). OEKO-TEK 100 label aims to ensure that products pose no risk to health. OEKO-TEK certified products do not contain allergenic dye-stuffs and dye-stuffs that form carcinogenic aryl-amines. The certification process includes thorough testing for a long list of chemicals. Specifically banned are: AZO dyes, carcinogenic and allergy-inducing dyes, pesticides, chlorinated phenols, extractable heavy metals, emissions of volatile components, and more.
- Investigate PFOS- and PFOA-free water repellants.
- Investigate using waterproof membranes from renewable resources.

AVAILABILITY

OEKO-TEK® Standard 100 certified polyamide is available. Manufacturers can be found at: www.OEKO-TEK.com

Non-toxic methods of waterproofing and flame retardancy are available.

Recycled polyamide is available globally in United States, Europe, Slovenia, Croatia, China, Japan and Israel.[15,16]

APPLICATIONS

Jackets, lingerie, swimwear, exercise wear, hosiery, jackets, bedspreads, carpets, upholstery, tents, fish nets, sleeping bags, rope, parachutes, luggage.

Some companies are producing versions of mechanically recycled polyamide that are of almost equal quality to virgin polyamide.

MARKETING OPPORTUNITIES

X% Recycled Content Regulations require stating percent recycled if not 100% recycled content.

non-toxic DWR methods If used and verified.

non-toxic methods of waterproofing If used and verified.

OEKO-TEK® Standard 100 certified If verified and used.

XX% bio-based If verified and used.

INVESTIGATE USING WATERPROOF MEMBRANES FROM RENEWABLE RESOURCES, SUCH AS CASTOR OIL.

The North Face's "Venture Jacket," which contains 50% caster-oil based waterproofing.

Image source: www.thenorthface.com

INNOVATION OPPORTUNITIES

1. Investigate alternative technologies for colouring polyamide fabrics, such as transfer printing, which eliminates water from the dyeing process.[17]

2. Design garments and products with reusable elements for easy disassembly. Design the product so that trims, tags, buttons, etc., can be easily separated from the main body of the product at the end of its useful life, to enable easy in-house recycling. Create collection systems for the products. Collect, disassemble, reuse.

3. Create internal store collections of polyamide 6 and 6,6 garments and products. Use fabric from collected garments and products to innovatively redesign new products and prolong the lifecycle.

4. Work with partners to develop closed loop recycling of polyamide 6 and 6,6 fibres and infrastructure to label, collect, sort and purify garments.

5. Explore the unique aesthetics of recycled polyamide to encourage innovative design of products.

6. In the cases where recycled polyamide 6 and 6,6 affect the aesthetic of the garment, craft marketing messages to turn potential negatives into positives.

7. Explore alternative fibres in replacement of polyamide that utilize cleaner manufacturing process, enable easier recycling or are biodegradable.

8. Get your product Cradle to Cradle Certified. The Cradle to Cradle Certified™ Product Standard is a multi-attribute, continuous improvement methodology that provides a path to manufacturing healthy and sustainable products. The Standard rewards achievement in five categories and at five levels of certification. An accredited assessor will help to assess and optimize your product.

9. Be knowledgeable about the most environmentally impacted stages of the polyamide lifecycle. Work with partners to decrease impacts of these stages.

1. www.ensinger-online.com/en/materials/engineering-plastics/polyamides/
2. antron.net/na/pdfs/literature/K02510_N66vsN6_Tech_Bulletin_06_18_13.pdf
3. Freinkel, Susan. PLASTIC A Toxic Love Story. New York: Houghton Mifflin Harcourt, 2011.
4. www.engr.utk.edu/~mse/Textiles/Nylon%20fibres.htm
5. www.atsdr.cdc.gov/csem/benzene/docs/benzene.pdf
6. www.patagonia.com/pdf/en_US/fluorochemicals.pdf
7. Grose, Lynda and Kate Fletcher. Fashion & Sustainability: Design for Change. London: Laurence King Publishing Ltd, 2012.
8. www.epa.gov/ttnchie1/le/acrylon.pdf
9. denr.sd.gov/des/wm/sw/documents/OpenBurningChemicalList.pdf
10. The Textile Dyer, "Concern over Recycled Polyester," May 13, 2008.
11. oecotextiles.wordpress.com/2009/07/14/why-is-recycled-polyester-considered-a-sustainable-textile/#_ftn6
12. hrd.apec.org/images/a/aa/62.4.pdf
13. www.chemsystems.com/about/cs/news/items/PERP%200910_1_Caprolactam.cfm
14. www.OEKO-TEK.com/media/downloads/Factsheet_OETS_100_EN.pdf
15. www.aquafil.com/en/about-us/worldwide.html
16. www.thecleanestline.com/2009/03/closing-the-loop-a-report-on-patagonias-common-threads-garment-recycling-program.html
17. www.triplepundit.com/2009/07/airdye-dyeing-fabric-without-water/

POLYESTER

Finding innovations that mitigate the ecological impacts of polyester will not only reduce environmental impacts, but has the potential to influence the textile industry as a whole.

Over the last 45 years technical developments in polyester production have improved the fibre's hand-feel, fineness and quality. Polyester is now the world's favorite fibre, representing 79% [in 2009] of world synthetic fibre production, fuelled in part by its use in fast-fashion garments, the fastest growing sector of the fashion industry.[1, 2, 3] Europe's share in the polyester industry accounted for 960,000 tonnes in 2009-2010.[1]

Polyester is a man-made, synthetic fibre. To produce polyester, crude oil (petroleum) is broken down into petrochemicals, which are then converted with heat and catalysts such as antimony into polyethylene terephthalate (PET). This is the same type of plastic used in plastic soda bottles.

BENEFITS

Polyester fabrics are readily available, strong, resistant to stretching and shrinking, resistant to most chemicals, and don't easily succumb to wrinkling, mildew or abrasion. So, when polyester fabrics are used in robustly constructed garments, they have the potential to last and to be worn many times, optimizing the **embodied energy and resources** in the garment. see comment in Potential Impacts below for counterpoint to this benefit

Polyester's positive attributes for clothing lie mostly in the consumer use phase of its lifecycle, which accounts for 50-80% of a polyester garment's total ecological footprint. Polyester garments are generally washed in cold water and drip-dried, thereby minimizing water and energy use associated with garment care.[4]

In comparison to other synthetic fibres, there is currently more research and innovation when it comes to sustainability and improving polyester's environmental impact.

POTENTIAL IMPACTS

PROCESSING

Petroleum, the main ingredient in manufacturing polyester, is a non-renewable resource and mining for petroleum destroys natural habitats. That is to say that petroleum takes millions of years to form, and is currently being extracted from the earth for industrial uses faster than it can be replenished. The declining petroleum supply is the source of much debate—British Petroleum (BP) reports that there are 1,333 billion barrels still available to pump (enough for 40 years at current usage rates).[5] Other sources state that supply is overestimated and that reserves are about 30% lower than widely reported.[6]

The manufacturing process for polyester is fully chemical, energy intensive and releases greenhouse gasses into the environment.[7]

In the production of polyester, the main ingredients used are terephthalic acid (TA) or dimethyl terephthalate, which are reacted with ethylene glycol, based on bromide-controlled oxidation.[7] The production of polyester emits emissions to air and water, which include: heavy metal cobalt; manganese salts; sodium bromide; antimony oxide; and titanium dioxide.

Antimony is of particular concern, since it is a toxic heavy metal known to cause cancer under certain circumstances and is a suspected reproductive toxin.[7] The function of antimony in the production of polyester is as a catalyst in the oxidation process. But it is not absolutely necessary for polyester production, and alternate non-antimony catalysts are available.

Europe meets its oil consumption/needs by importing from foreign sources: 41% from the Russian Federation, 26% from Africa, 16% from the Middle East—14% comes from Europe—thus requiring transportation over long distances.[8,9] Fuel released by vehicles used to transport the oil causes pollution and CO2 emissions.

POTENTIAL IMPACTS cont'd

DYEING AND FINISHING

Certain types of dyes are suspected carcinogens and mutagens, while other dyes are known to have a sensitizing effect on skin and should be avoided. Untreated dye water can negatively impact receiving water bodies and harm aquatic ecosystems if left untreated before its release.

MORE INFO PART 5: DYEING & PRINTING

CONSUMER CARE/ WASHING

Certain at-home detergents have been reported to have detrimental effects on humans and the environment, contributes to ozone depletion and can pollute wastewater.

MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

Polyester has durability to last the wearer several years, however it is typically used in inexpensive, **fast-fashion** garments that are worn and quickly discarded. Synthetic fibres are from a carbon-based chemical feedstock and are considered **non-biodegradable**.[10]

MORE INFO APPENDIX: BIODEGRADABILITY

There are conflicting opinions about how long polyester takes to decompose and estimates range from 40 years to 1000 years. This is because degradability is dependent upon a number of conditions including how much air, temperature and sunlight the fibre is exposed to.

Discarded polyester products increase load on landfills, contribute to water contamination and possibly toxic emissions into the air.[11] According to a study done by Mark Browne, an ecologist at University College Dublin, microscopic fragments of polyester, acrylic, polyethylene, polypropylene, and polyamide have been discovered in increasing quantities across the northeast Atlantic, as well as on beaches in Britain, Singapore and India. A chemical analysis revealed that nearly 80% of the filaments contained polyester or acrylic.[12]

MORE INFO APPENDIX: WASTE TO ENERGY

ALTERNATIVES TO VIRGIN POLYESTER

RECYCLED POLYESTER

Using recycled polyester achieves two main ecological benefits: 1) it slows the depletion of virgin natural resources, and 2) it reduces textile waste building in landfills. Polyester can be recycled into new versions of the same product or into entirely different products.

Post-consumer waste from used and discarded products and **post-industrial waste** from material collected during the product manufacturing can be recycled. There are two processes for recycling polyester: mechanical and chemical.

mechanical recycling

Since polyester is a thermoplastic and is melt-spun, it can be effectively re-melted and remolded to make yarns. However, in this manner the fibre is "**downcycled**": its physical structure breaks down, and eventually the product must be discarded to landfill.[13]

Collection, sorting and purifying discarded synthetic garments (i.e., post-consumer waste) is currently cumbersome. Infrastructure for labeling, collection and sorting needs to be improved so that the post-consumer raw material source can scale to be economically viable.

Polymer resins come in a variety of forms and some are relatively easy to collect and recycle. The most well known source is soda bottles, which can be used to make new PET (polyethylene terephthalate) fibre. The bottles are collected, sorted by colour (green vs. clear), thoroughly inspected to ensure that no caps (often polypropylene), bases or PVC bottles are present. (This is critical, because one stray PVC bottle in a melt of 10,000 PET bottles can ruin the entire batch of new fibre.) Following inspection, the bottles are sterilized, dried and crushed into flakes, which are washed again, bleached and dried. The flakes are then emptied into a vat, heated, melted and extruded through spinnerets, to form long polyester fibres. Flakes from green bottles are generally used for fibres that will be dyed in dark colours, though some companies take advantage of the green colour in the new fabric developed.

chemical recycling

Chemical recycling involves breaking the polymer into its molecular parts and reforming the molecules into a yarn of equal strength and quality as the original, in perpetuity.[14] In this process, the chemical building blocks are separated (depolymerization) and reassembled (repolymerization), forming what is known as a "**closed loop**" where the final stage of the product lifecycle (disposal) forms the first stage of the next product (raw fibre). Closed loop recycled polyester processing is expensive in part because it is a relatively new technology. In addition, the infrastructure to label, collect, sort and purify discarded garments at scale is being developed.

In 2002, the Japanese company Teijin launched ECO CIRCLE™, the first closedloop chemical recycling system for polyester. Teijin works with fabric suppliers and apparel brands to manufacture products using recycled and recyclable materials, and is also helping to develop post-consumer clothing collection programs.

Teijin recently established a joint venture with one of China's largest fibre producers, bringing the manufacture of chemically processed recycled polyester to China.[15]

POLYMER RESINS COME IN A VARIETY OF FORMS AND SOME ARE RELATIVELY EASY TO COLLECT AND RECYCLE. THE MOST WELL KNOWN SOURCE IS SODA BOTTLES, WHICH CAN BE USED TO MAKE NEW PET (POLYETHYLENE TEREPHTHALATE) FIBRE.

MECHANICAL RECYCLING VS. CHEMICAL RECYCLING:

PROCESS	BENEFITS	CONSIDERATIONS	IMPACTS
Mechanical recycling	• Slows the depletion of non-renewable resources • Fewer CO2 emissions than virgin polyester • Diverts textile waste from landfills	• Difficult to label, collect, sort and purify post-consumer garments on a large scale • Some fabrics with chemical backing, lamination, finish or those used in complex blends with other synthetics (nylon, for example) are not physically recyclable.[14] • Recycled polyester from PET bottles is particularly suited for use in fabric such as polar fleece, where the construction of the fabric hides slight yarn variations.[14] • This process degrades the fibre and eventually the product is disposed of in the landfill. • Beware: The demand for used PET bottles is now surpassing supply in some areas and reports indicate that some suppliers are buying new bottles to make polyester textile fibre that can be called recycled.[14]	• Since the base colour of recycled polyester chips varies, colour inconsistencies in the fabric may occur, and this can lead to the need for re-dyeing. Re-dyeing greatly increases levels of water, energy and chemicals used.[14] • Whites can also be difficult to achieve in recycled fibres, and some processors use chlorine-based bleaches to whiten the base fabric. The dyeing and bleaching process for recycled fabrics involves standard industry chemicals.
Chemical recycling	• Slows depletion of non-renewable resources • Generates fewer CO2 emissions than virgin polyester • Diverts textile waste from landfills • Creates a completely new yarn of equal strength and quality to virgin polyester, in perpetuity.	• Difficult to label, collect, sort and purify discarded polyester garments on a large scale. • Some fabrics with chemical backing, lamination, finish or those used in complex blends with other synthetics are not chemically recyclable.[14]	• Uses significant amounts of energy.

ALTERNATIVES TO VIRGIN POLYESTER cont'd
BIOPOLYMER FIBRES
Polylactide (PLA)

Polylactide (PLA) is a renewable thermoplastic and a polymer. It is derived from the starch of plants such as corn, sugar cane and sugar beet. PLA is biodegradable, as it decays as a result of exposure to heat and moisture. It decomposes forming carbon dioxide and water, which present no danger to the environment.[16,17]

PLA's ability to biodegrade comes as a result of its hydrolysis and low melting point. These features could hinder PLA's ability to be suitable in some applications, such as the outdoors or fabric that needs to be ironed. However, efforts to address these drawbacks in PLA have recently been accomplished. NatureWorks LLC, which offers a brand name of PLA called Ingeo, has developed hydrolytic stabilizers that can be implemented in certain applications to prevent degradation outdoors. The company is currently working to increase the melting point of PLA so that it can be ironed.[18]

MORE INFO PART 4: BIOPOLYMERS

JACKET MADE FROM 100% INGEO PLA.

Nordic Initiative Fashion Summit winner Saara Lepokorpi.

Image source: ides.typepad.com

OPTIMIZE SUSTAINABILITY BENEFITS

- Promote the use of recycled polyester that has been recycled using a chemical process.
- Promote the use of mechanically recycled polyesters from producers that use high quality raw materials.
- Promote the use of antimony-free polyester.
- Promote the use of polylactide (PLA).
- If using recycled polyester from PET bottles, ensure that the supplier is using recycled bottles, rather than new ones.[15]
- Promote the use of low-impact dye and bleaching processes.
- Promote the use of OEKO-TEK certified polyester.[19] OEKO-TEK is an independent, third party certifier that offers two certifications for textiles: OEKO-TEK 100 (for products) and OEKO-TEK 1000 (for production sites/factories). OEKO-TEK 100 label aims to ensure that products pose no risk to health. OEKO-TEK certified products do not contain allergenic dye-stuffs and dye stuffs that form carcinogenic aryl-amines. The certification process includes thorough testing for a long list of chemicals. Specifically banned are: AZO dyes, carcinogenic and allergy-inducing dyes, pesticides, chlorinated phenols, extractable heavy metals, emissions of volatile components, and more.

AVAILABILITY

Due in part to the volume of discarded soda bottles, mechanically recycled polyester is readily available to textile and apparel suppliers.

Companies such as Freudenberg Politex in Italy, and REPREVE® and Poole Company in the United States are producing versions of mechanically recycled polyester that are of almost equal quality to virgin polyester because of the high quality of raw materials used.

Chemically recycled polyester is gaining in popularity and the number of companies offering fabrics made from this technology is increasing globally. The Japanese company Teijin which first developed chemical recycling technology, recently established a joint venture to establish fabric manufacturing in China.

Eco Intelligent™, antimony-free polyester, is available through Victor Group in North America. Antimony free tititanium-based catalysts are available from Johnson Matthey's catalyst Vertec and Teijin's "heavy metal free" polyester chip.[20, 21]

Polylactide (PLA) is still a developing technology. NatureWorks LLC makes Ingeo, a PLA.

APPLICATIONS

Chemically recycled polyester fibres maintain the same quality as virgin polyester fibres in perpetuity

Mechanically recycled polyester fibres can be of almost equal quality to virgin polyester, depending on the quality of raw materials. Some producers use low quality materials which result in low quality fibre.

Mechanically recycled polyester fibres can be blended with other fibres to maintain strength and quality for applications in a variety of fabric constructions—activewear, intimates, outdoor wear, T-shirts, trousers, etc.

Polylactide (PLA) is still a developing technology, and currently can be used for applications of bedding and apparel.

MARKETING OPPORTUNITIES

x% recycled content Regulations require stating percent recycled if not 100% recycled content. In some cases where recycled polyester affects the aesthetic of the garment, craft marketing messages to turn potential negatives into positives.

antimony-free If non-antimony polyester is used.

alternative dyes If used.

made from renewable source If PLA is used.

INNOVATION OPPORTUNITIES

1. Although creating different blends of recycled polyester with recycled cotton, organic cotton, etc., is good in the short term, know that these blends make it difficult to recycle at End of Use stage, and create liabilities and waste. When designing fibre blends, consider what happens after End of Use.

2. Design garments and products with reusable elements and for easy disassembly. Design the product so that trims, tags, buttons, etc. can be easily separated from the main body of the product at the end of its useful life, to enable easy in-house recycling. Create collection systems for the products. Collect, disassemble, reuse.

3. Look for cross-sector marketing opportunities. For example, partner with a soft drinks brand to use their PET bottles in fabrics, or partner with garment collection charity to establish a long term collection facility where customers can drop their closed loop recyclable polyester garments.

4. Investigate alternative technologies for colouring polyester fabrics, such as AirDye, which eliminates water from the dyeing process.[17] Explore unique aesthetics achieved from using this process.

5. Design garments that are 100% polyester, including trims, so garments can be chemically recycled easily at the end of use.

6. Design products so that non-polyester trims can be easily separated from the main body of the product at the end use, to enable easy polyester recycling.

7. Design 100% degradable garments that are made from 100% PLA and work directly with the fibre-producing company to ensure performance and proper application. Create in-store take-back program for customers and partner with a local compost facility to ensure optimum conditions for garment to degrade properly.

8. Get your product Cradle to Cradle Certified. The Cradle to Cradle Certified™ Product Standard is a multi-attribute, continuous improvement methodology that provides a path to manufacturing healthy and sustainable products. The Standard rewards achievement in five categories and at five levels of certification. An accredited assessor will help to assess and optimize your product.

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POLYETHYLENE

The main consideration with polyethylene is that it's non-biodegradable and can be toxic to marine life. Efforts to look at strategies to decrease overall consumption could influence the environmental impact that polyethylene has on the world around us.

MANUFACTURED FIBRE

Polyethylene (PE) is a synthetic, manufactured plastic that is the most commonly used polymer in the world. It constitutes about one third of all plastics produced worldwide, and its applications are mainly bags, packaging and industrial uses.

BENEFITS

Polyethylene is tough, flexible, lightweight (some are featherweight), waterproof and easy to process.

There are three main types of polyethylene, including low-density polyethylene (LDPE), linear-low-density polyethylene (LLDPE) and high-density polyethylene (HDPE).

Products in these categories include diverse applications: bags for newspapers, dry-cleaning, frozen foods; sandwich bags; shrink-wrap; squeezable bottles; coatings on milk cartons and hot and cold beverage cups; lids; toys; flexible tubing; plastic grocery bags; retail shopping bags, milk jugs; juice, detergent and household cleaner bottles; safety protective clothing; and apparel/product bags for shipping.

Polyethylene is inexpensive. It costs less than a penny to manufacture 140 grams, and .06 to .13 SEK for a plastic bag.[1]

POTENTIAL IMPACTS

PROCESSING

The manufacturing process for polyethylene requires non-renewable resources and high water use. For the production of 1 kg of high-density polyethylene (HDPE), for example, 1.5 kg of fossils fuels are required, and over 3 kg of water.[1]

Fuel released by vehicles used to transport oil and waste causes pollution and CO2 emissions.[2]

END OF USE

Polyethylene's most substantial environmental impact is at its end of use stage. Despite its durability (plastic bags can hold more than 100 times their weight), polyethylene was not designed for longevity, but for immediate throwaway.

MORE INFO APPENDIX: BIODEGRADABILITY

Carbon dioxide emissions are released when high-density polyethylene is incinerated. This could happen in countries that do not have access to more sophisticated disposal, recycling and waste-to-energy methods.[3]

MORE INFO APPENDIX: WASTE TO ENERGY

ALTERNATIVES TO VIRGIN POLYETHYLENE

RECYCLED POLYETHYLENE

Using recycled polyethylene achieves two main ecological benefits: 1) it slows the depletion of virgin natural resources, and 2) it reduces textile waste building in landfills. Polyethylene can be recycled into new versions of the same product or into entirely different products.

Post-consumer waste from used and discarded products and **post-industrial waste** from material collected during the product manufacturing can be recycled.

Mechanical recycling

Polyethylene can be effectively collected, cleaned, cut, re-melted and remolded. However, the material is "**downcycled**" in this manner, which means that its physical structure breaks down, and eventually the product must be discarded to landfill.[4] Infrastructure for collection, sorting and purifying must be in place.

OPTIMIZE SUSTAINABILITY BENEFITS

- Encourage the use of bio-derived polyethylene. Bio-derived polyethylene is derived from renewable resources, such as sugar cane. Bio-plastics have a lower carbon footprint, and some are recyclable and compostable. There is no guarantee that they are manufactured with less harmful chemicals or contain less toxic additives.

- Encourage the use of recycled polyethylene.

AVAILABILITY

Recycled polyethylene is readily available globally.

APPLICATIONS

(FOR FASHION AND TEXTILE INDUSTRY)

Apparel shipping bags, shopping bags.

MARKETING OPPORTUNITIES

X% Recycled Content Regulations require stating percent recycled if not 100% recycled content.

XX% bio-based If verified and used.

ENCOURAGE THE USE OF BIO-DERIVED POLYETHYLENE MADE FROM RENEWABLE RESOURCES, LIKE SUGAR CANE.

INNOVATION OPPORTUNITIES

1. Instead of "throwaway living," develop ways to reuse polyethylene for garment shipping of apparel and products to stores.

2. Investigate alternative fibres to replace polyethylene bags for garment product shipping. Look for innovations beyond replacing polyethylene bags with cotton or polyester bags with messages such as "not a plastic bag."

3. Create internal store collections of polyethylene bags. Redistribute bags to consumers.

4. Work with partners to develop closed loop recycling of polyethylene and infrastructure to collect and sort.

5. Increase awareness and participation of the public, and find simple, acceptable alternatives to polyethylene bag use.

6. Reward customers for reusing bags. Eye-catching signs raise awareness and encourage people to reuse bags.

7. Develop a 100% compostable shopping bag that biodegrades in less than 2 months.

8. Design polyethylene products with reuse in mind in order to optimize resources embodied in the product.

9. Work with suppliers to advance technology for bio-based plastics from organic feedstock.

10. Stop giving customers shopping bags to encourage them to bring their own.

1. www.plasticseurope.org/Documents/Document/20100312112214-FINAL_HDPE_280409-20081215-017-EN-v1.pdf
2. www.epa.gov/climatechange/wycd/waste/downloads/plastics-chapter10-28-10.pdf
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POLYPROPYLENE (PP)

The main environmental consideration—along with all other synthetics in this category—is that this material, whether in fibre form or other, is non-biodegradable and intended for short-term usage. Global polypropylene usage is at 2.6 million tonnes, and efforts to address sustainability innovations could make a significant impact on the industry and the planet.[1]

MANUFACTURED FIBRE

Polypropylene (PP) is a long-chain synthetic polymer composed of at least 85% by weight of ethylene, propylene or other olefin units. Polypropylene is a manufactured and man made polyolefin fibre and used in a number diverse applications ranging from carpet to technical and outdoor apparel to geotextiles and product packaging.

BENEFITS

Polypropylene's characteristics have been perfected over the years since it was originally developed in the 1950s. It has excellent durability, strength and resiliency while still being lightweight. Polypropylene has good resistance to ultraviolet degradation, stains and spilling, and excellent wicking action—which make this material great for carpets.[2] These features also eliminate the need for water and stain-repellent finishes.

Polypropylene's natural buoyancy also makes it perfect for high performance apparel such as wetsuits and swimsuits.

Polypropylene blends well with other fibres, and when used capitalizes on its excellent wicking properties.[2]

No dyeing is necessary—which means no pollution from dyeing— since colours are incorporated during the fibre-forming stage.[3]

Its low softening point encourages consumers to launder their products in low temperature washing and ironing, thereby minimizing water and energy use associated with consumer care and washing.[4]

POLYPROPYLENE'S NATURAL BUOYANCY MAKES IT PERFECT FOR HIGH PERFORMANCE APPAREL SUCH AS WETSUITS AND SWIMSUITS.

POTENTIAL IMPACTS

PROCESSING

Typical of synthetic fibres, production for polypropylene varies amongst manufacturers. Individual manufacturers have variations in their processes to achieve certain properties such as dyeability, light stability and heat sensitivity.[5]

The manufacturing process for polypropylene requires non-renewable resources and high water and energy use.[6, 7, 8]

Fuel released by vehicles used to transport oil and waste causes pollution and CO2 emissions. [9]

END OF USE

Polypropylene's most substantial environmental impact is at its End of Use stage. Polypropylene is non-biodegradable, and polypropylene products increase load on landfills and end up in oceans and large bodies of water, where they can harm aquatic species and potentially end up back in our food and water. According to a study done by Mark Browne, an ecologist at University College Dublin, microscopic fragments of acrylic, polyethylene, polypropylene, polyamide and polyester have been discovered in increasing quantities across the northeast Atlantic, as well as on beaches in Britain, Singapore and India.[10]

MORE INFO APPENDIX: BIODEGRADABILITY

ALTERNATIVES TO VIRGIN POLYPROPYLENE

RECYCLED POLYPROPYLENE

Using recycled polypropylene achieves two main ecological benefits: 1) it slows the depletion of virgin natural resources, and 2) it reduces textile waste building in landfills. Polypropylene can be recycled into new versions of the same product or into entirely different products.

Post-consumer waste from used and discarded products and **post-industrial waste** from material collected during the product manufacturing can be recycled.

Mechanical recycling

Polypropylene can be effectively collected, cleaned, cut, re-melted and remolded. However, the material is "downcycled" in this manner, which means that its physical structure breaks down, and eventually the product must be discarded to landfill. Infrastructure for collection, sorting and purifying must be in place.

Note: Recycled polypropylene still uses significant amounts of energy throughout the production process.

AVAILABILITY

Recycled polypropylene is available from suppliers in Europe and China.

Bio-derived polypropylene is currently an advancing technology and is not readily available.

APPLICATIONS

High performance gear for backpacking/canoeing/mountain climbing, wetsuits, swimsuits, running/cycling clothing, inexpensive carpets, upholstery, industrial uses.

OPTIMIZE SUSTAINABILITY BENEFITS

- Promote the use of recycled polypropylene.
- Promote the research of bio-derived polypropylene. Bio-derived polypropylene is derived from renewable resources, such as sugar cane. Bio-plastics have a lower carbon footprint, and some are recyclable and compostable. There is no guarantee that they are manufactured with less harmful chemicals or contain fewer toxic additives. Also, plants used for bio-plastic feedstock can be grown without fertilizers and pesticides.[12, 13, 14]
- Promote OEKO-TEK certified polypropylene.[15] OEKO-TEK is an independent, third party certifier that offers two certifications for textiles: OEKO-TEK 100 (for products) and OEKO-TEK 1000 (for production sites/factories). OEKO-TEK 100 label aims to ensure that products pose no risk to health. OEKO-TEK certified products do not contain allergenic dye-stuffs and dye-stuffs that form carcinogenic aryl-amines. The certification process includes thorough testing for a long list of chemicals. Specifically banned are: AZO dyes, carcinogenic and allergy-inducing dyes, pesticides, chlorinated phenols, extractable heavy metals, emissions of volatile components, and more.

MARKETING OPPORTUNITIES

X% Recycled Content Regulations require stating percent recycled if not 100% recycled content.

XX% bio-based If verified and used.

INNOVATION OPPORTUNITIES

1. At the product design stage, consider what will happen to a polypropylene product at the End of Use stage of the lifecycle. Design products that address longevity, recyclability, biodegradability, disassembly for reuse, etc.
2. Work with partners to develop closed loop recycling of polypropylene products and infrastructure to collect and sort.
3. Look to suitable fibre alternatives for polypropylene that have more advanced technology and infrastructure for recycling and biodegradability, such as polyester and polylactide (PLA).
4. Work with suppliers to advance technology for bio-based plastics from organic feedstock.
5. Design polypropylene products with reuse in mind in order to optimize resources embodied in the product.
6. Get your product Cradle to Cradle Certified. The Cradle to Cradle Certified™ Product Standard is a multi-attribute, continuous improvement methodology that provides a path to manufacturing healthy and sustainable products. The Standard rewards achievement in five categories and at five levels of certification. An accredited assessor will help to assess and optimize your product.

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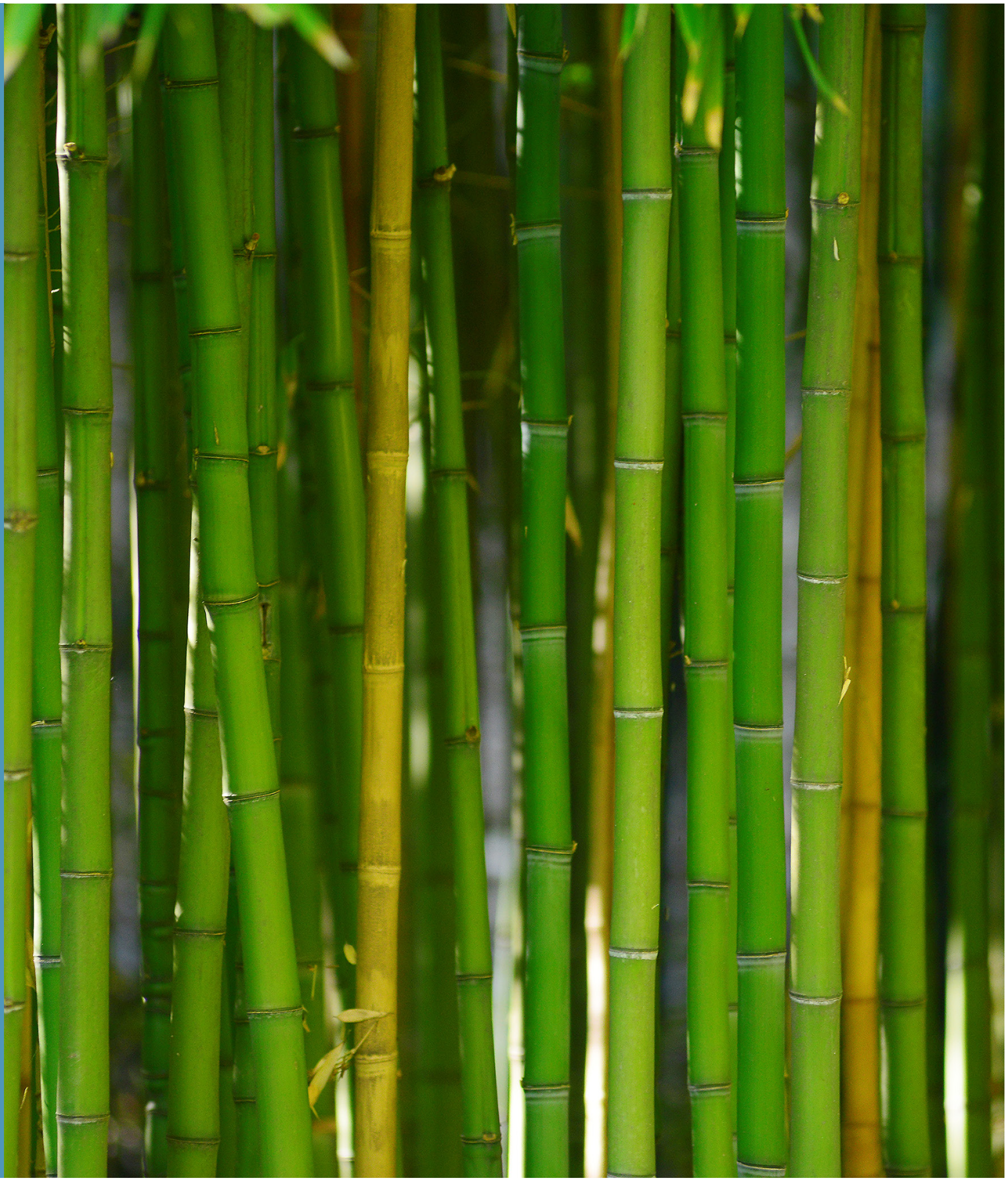
VISCOSE MADE FROM BAMBOO

Viscose made from bamboo is categorized as a “manufactured” or “man-made” fibre created from cellulose found in the bamboo plant. It is derived from bamboo, which is then chemically processed and regenerated to form a new polymer using the viscose process.

MANUFACTURED FIBRE



BENEFITS

Bamboo is a "rapidly renewable" resource, meaning that it grows quickly and can be harvested at least once a year.

FAST-GROWING RENEWABLE FIBRES

FIBRE	LENGTH	TIMING
Bamboo (for linen or viscose)	24 meters	40 days[1]
Jute	1-4 meters	3-4 months[2]
Hemp	4 meters	3 months[3]
Flax	1 meter[4]	3-4 months[5]

Bamboo is a biologically efficient, low maintenance crop that requires few chemical inputs during the growing season. It is mainly rain fed, and can grow in diverse climates.

Due to its speedy growth and little input needed for growing, some say that using bamboo as an alternative to slower growing wood trees could help slow deforestation.[1]

Viscose from bamboo drapes well, is easy to dye, and is highly absorbent. It is a good conductor of heat, so it is a cool, comfortable fibre good for use in warm weather. Viscose made from bamboo is priced for its softness and comfort.

POTENTIAL IMPACTS

CULTIVATION

Some species of bamboo are highly invasive, meaning they take over natural vegetation.

PROCESSING

To transform plant-derived materials into silky fabric, the cellulose must be separated from other compounds found in bamboo. Sodium hydroxide (caustic soda) and sodium sulfide are commonly used to remove the lignin that binds the plant fibres together, and in some cases bleach is required to whiten the pulp. In a complex process, the pulp is steeped in caustic soda to produce alkali cellulose, which is then aged or oxidized before reacting with carbon disulfide to create sodium cellulose xanthate. This xanthate is dissolved in caustic soda to form a syrup-like spinning solution or "viscose," which can then be extruded through a spinneret to form viscose fibres.[6]

The viscose manufacturing process is chemically intensive and requires copious amounts of water. Wastewater effluents from processing must be properly treated to avoid contamination of surrounding water bodies. Air emissions caused by the viscose process include sulfur, nitrous oxides, carbon disulfide and hydrogen disulfide. Chronic exposure to carbon disulfide can cause damage to the nervous system in humans.[6]

DYEING AND FINISHING[7, 8, 9]

The dyeing processes for viscose made from bamboo is a multi-step process that involves ample amounts of water at high temperatures (50°-95°C), salt, acetic acid and caustic soda. Mild peroxide bleach may also be necessary to remove residues of sulphur.

MORE INFO PART 5: DYEING & PRINTING

CONSUMER CARE/WASHING

Viscose made from bamboo is typically dry-clean only, due to delicacy of the fabric when wet. Some types of viscose can be machine or handwashed.

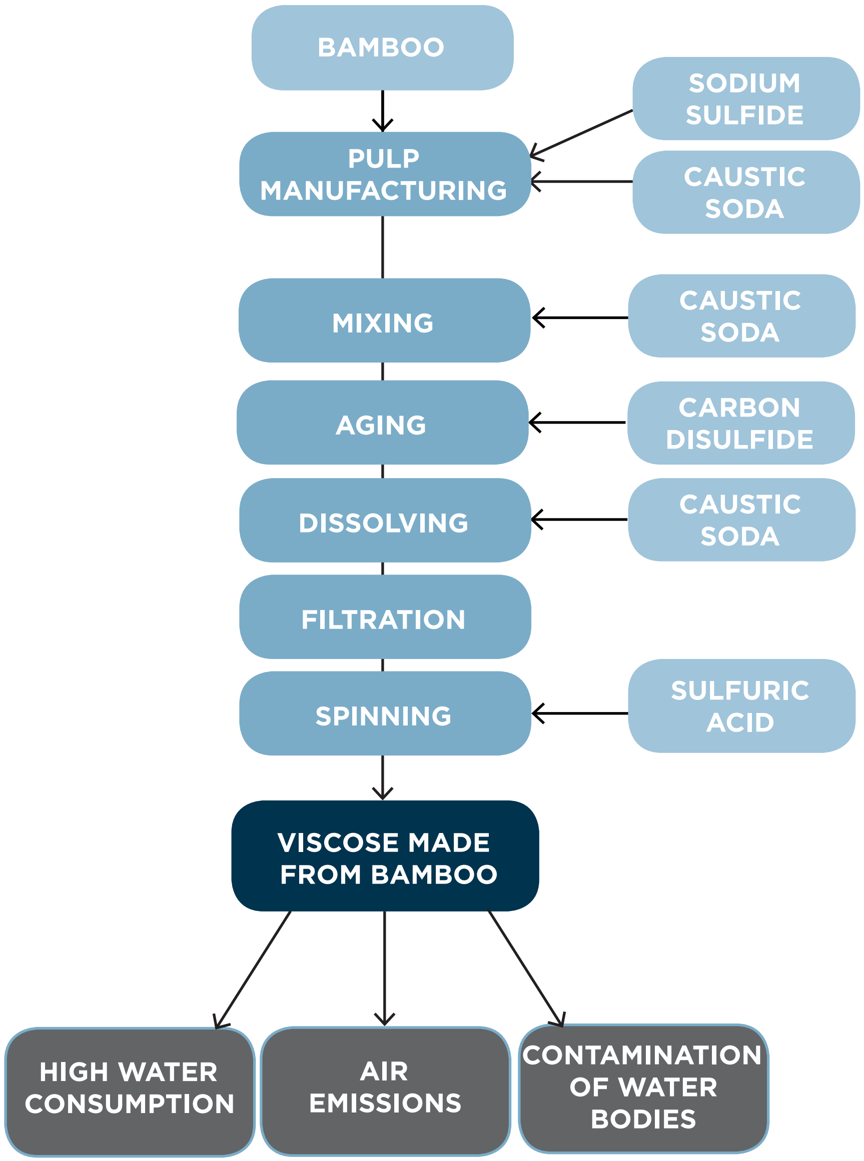
MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

Viscose made from bamboo products are non-biodegradable because they can not beak down within a reasonably short time after disposal into a landfill.[10]

MORE INFO APPENDIX: BIODEGRADABILITY

PROCESS FOR VISCOSE MADE FROM BAMBOO



OPTIMIZE SUSTAINABILITY BENEFITS

- Know the difference between linen made from bamboo and viscose made from bamboo. Viscose made from bamboo employs a chemically intensive process and has high environmental and social impacts due to emissions to air and water during processing.
- Encourage suppliers to use raw materials sourced from **Programme for the Endorsement of Forest Certification schemes (PEFC)** and **Forest Stewardship Council (FSC)** certified plantations.
- Investigate viscose processing methods that use enzymes instead of chemicals.
- New forms of viscose-type materials are emerging, and can be made through various types of processes including lyocell. Lyocell fibre production is similar to that of generic viscose in that bamboo material is dissolved through an intensive chemical process into a pulp, which is then extruded to form fibres. However, for lyocell, the solvent used to transform the pulp into fibre is amine oxide (NMMO=N-Methyl-Morpholine-N-Oxide), which is considered non-toxic. The lyocell fibre manufacturing process also operates as a **closed loop system**, in which 99% of the solvent is recovered, filtered and reused. Any remaining emissions are broken down harmlessly in biological wastewater treatment plants. [11]

AVAILABILITY

Few suppliers are currently offering viscose made from bamboo from PEFC and FSC certified plantations. Expressing interest in PEFC and FSC certification can influence the supplier's raw material sourcing strategy and lead to greater availability of responsibly sourced feedstock for viscose made from bamboo fabric.

Texplan, a Spanish company, is working with suppliers in China to produced lyocell fibre made from bamboo that is also FSC certified.[12]

Litrax, a Swiss company, has developed a process that uses enzymes instead of chemicals for processing bamboo into viscose. [13]

APPLICATIONS

Viscose made from bamboo and lyocell made from bamboo fabrics can be used in a variety of textile woven and knitted applications. Depending on the weight and construction of the cloth, these fabrics may be suitable for shirts, skirts, dresses, evening gowns, home furnishings and bedding.

MARKETING OPPORTUNITIES

viscose Bamboo is being marketed strongly as an eco-friendly fibre. While the raw material is a rapidly renewable natural resource, viscose made from bamboo fabric employs a highly pollutive process in its manufacture. The European Commission has issued a directive on textile names, 2008/121/EC. This directive states how textile products should be marketed and sold in the EU. The name "bamboo" does not appear in this directive; therefore, it cannot be used for the purposes of compulsory description of fibre composition. The name "viscose" is included in this directive and should be used to describe the fibres corresponding to the definition: "regenerated cellulose fibre obtained by the viscose process for filament and discontinuous fibre." This includes viscose made from bamboo fibres. This should be done consistently on labeling, hangtags and POS.[14]

MORE INFO PART 2: BAMBOO LINEN

bamboo lyocell If bamboo is processed with a lyocell process.

bamboo from PEFC or FSC certified plantations If verified and accurate.

fast-growing natural resource

low water footprint in cultivation

NOTE: Other companies are claiming that bamboo is a natural antibiotic. The Federal Trade Commission (FTC) in the U.S. notes that the chemical processing that bamboo needs to go through to make viscose eliminates any of the plant's antimicrobial properties.[5]

INNOVATION OPPORTUNITIES

1. Shift to existing environmentally beneficial fabrics when possible. These fabrics include fabric derived from organic cotton, recycled fabrics, hemp, flax, and dissolving pulp from bamboo and eucalyptus plantations that are PEFC and FSC certified.

2. Use bamboo from PEFC and FSC certified plantations, and produce the fabric with lyocell process. Communicate the difference between the viscose and lyocell processes to consumers on your website and hangtags.

3. Encouraging handwashing on the hangtag and labeling/POS would influence the consumer to take an active role in reducing environmental impacts of viscose at the consumer washing stage.

4. Get your product Cradle to Cradle Certified. The Cradle to Cradle Certified™ Product Standard is a multi-attribute, continuous improvement methodology that provides a path to manufacturing healthy and sustainable products. The Standard rewards achievement in five categories and at five levels of certification. An accredited assessor will help to assess and optimize your product.

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14. eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:019:0029:0048:EN:PDF
15. eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:019:0029:0048:EN:PDF
16. business.ftc.gov/documents/alt172-how-avoid-bamboozling-your-customers

VISCOSE MADE FROM WOOD

Viscose made from wood is categorized as a “manufactured” or “man-made” fibre created from cellulose found in trees. It is typically derived from spruce or pine (although any plants or trees can be used to make viscose) and is then chemically processed and regenerated to form a new polymer using the viscose process.

MANUFACTURED FIBRE

Although viscose is generally not considered a sustainable fibre due to its highly chemical process, new forms of viscose-type materials are emerging—such as lyocell—that have the same material characteristic, but are produced by non-toxic processes and operate in a **closed loop system** where outputs are recovered, filtered and reused.[1]

BENEFITS

Viscose is the oldest manufactured fibre. The viscose process was developed in the late 1800s as an inexpensive alternative to silk. Viscose has a silk-like aesthetic, drapes well, is easy to dye, and is highly absorbent. It is a good conductor of heat, so it is a cool, comfortable fibre good for use in warm weather.

Viscose is also relatively inexpensive compared to other fibres, and blends well with many fibres—sometimes used to reduce cost, or contribute lustre, softness, absorbency or comfort.[1]

POTENTIAL IMPACTS

CULTIVATION

Wood feedstock may be sourced from ancient and endangered forest.[2]

PROCESSING

To transform hardwood-derived materials into silky fabric, the cellulose must be separated from other compounds found in trees. Sodium hydroxide (caustic soda) and sodium sulfide are commonly used to remove the lignin that binds the wood fibres together, and in some cases bleach is required to whiten the pulp. In a complex process the pulp is steeped in caustic soda to produce alkali cellulose, which is then aged or oxidized before reacting with carbon disulfide to create sodium cellulose xanthate. This xanthate is dissolved in caustic soda to form a syrup-like spinning solution or "viscose," which can then be extruded through a spinneret to form viscose fibres.[3]

The viscose manufacturing process is chemically intensive and requires copious amounts of water. Wastewater effluents from processing must be properly treated to avoid contamination of surrounding water bodies. Air emissions caused by the viscose process include sulfur, nitrous oxides, carbon disulfide and hydrogen disulfide. Chronic exposure to carbon disulfide can cause damage to the nervous system in humans.[3]

DYEING AND PRINTING

The dyeing processes for viscose is a multi-step process that involves ample amounts of water at high temperatures (50°-95°C), salt, acetic acid and caustic soda. Mild peroxide bleach may also be necessary to remove residues of sulfur. MORE INFO PART 5: DYEING & PRINTING

CONSUMER CARE/WASHING

Viscose is typically dry-clean only, due to delicacy of the fabric when wet. Some types of viscose can be machine or handwashed.

Electricity and water use in the care of the garment can cause significant environmental impacts. Certain chemicals used in dry-cleaning and at-home products have been reported to have detrimental effects on humans and the environment, and contribute to ozone depletion and can pollute wastewater. MORE INFO APPENDIX: CONSUMER CARE & WASHING

END OF USE

According to the Federal Trade Commission (FTC) in the United States, viscose products are non-biodegradable because they will not break down in the required time under customary disposal conditions.[7]

Viscose is typically used in **fast-fashion** garments that are worn and quickly discarded. If these garments end up in landfill, they are likely to remain there for decades. MORE INFO APPENDIX: BIODEGRADABILITY

OPTIMIZE SUSTAINABILITY BENEFITS

- Discourage suppliers from using old-growth trees as feedstock for viscose fabrics, especially those harvested from the following endangered forest areas: Canadian boreal forest; coastal temperate Rainforests of the Pacific Northwest; US; Chile; Tropical forests of Indonesia; and the Amazon.[2]

- Encourage suppliers to use raw materials sourced from responsibly managed forests registered in the Forest Stewardship Council (FSC) certification system and/or sourced from **Programme for the Endorsement of Forest Certification schemes (PEFC)** and **Forest Stewardship Council (FSC)** certified forests.[2]

LENZING VISCOSE®

Lenzing Viscose® gives more attention to overall sustainability. The various chemical and waste products that result from the production process are recycled or sold. Viscose from Lenzing is PEFC certified, which means that the raw material is sourced from responsibly managed forests.

Lenzing Viscose® and Lenzing Modal® Austria are the only man-made fibres which are **carbon neutral**.

LYOCELL

New forms of viscose-type materials are emerging, and can be made through various types of processes, including lyocell. Lyocell material properties are similar to traditional viscose and fibre production is also similar to that of generic viscose in that hardwood material is dissolved through an intensive chemical process into a pulp, which is then extruded to form fibres. However, for lyocell, the solvent used to transform the pulp into fibre is amine oxide (NMMO=N-Methyl-Morpholine-N-Oxide), which is considered non-toxic. The lyocell fibre manufacturing process also operates as a **closed loop system**, in which 99% of the solvent is recovered, filtered and reused. Any remaining emissions are broken down harmlessly in biological wastewater treatment plants.[9]

OEKO-TEK CERTIFIED VISCOSE[10]

OEKO-TEK is an independent, third party certifier that offers two certifications for textiles: OEKO-TEK 100 (for products) and OEKO-TEK 1000 (for production sites/factories). OEKO-TEK 100 label aims to ensure that products pose no risk to health. OEKO-TEK certified products do not contain allergenic dye-stuffs and dye-stuffs that form carcinogenic aryl-amines. The certification process includes thorough testing for a long list of chemicals. Specifically banned are: AZO dyes, carcinogenic and allergy-inducing dyes, pesticides, chlorinated phenols, extractable heavy metals, emissions of volatile components, and more.

AVAILABILITY

There are a few suppliers in China that are currently offering viscose from PEFC and FSC certified forests. Expressing interest in PEFC and FSC certification can influence the supplier's raw material sourcing strategy and lead to greater availability of responsibly sourced feedstock for viscose fabric.

OEKO-TEK® Standard 100 certified viscose is available. Manufacturers can be found at: www.oeko-tex.com

APPLICATIONS

Viscose and lyocell can be used in a variety of textile woven and knitted applications. Depending on the weight and construction of the cloth, these fabrics may be suitable for shirts, skirts, dresses, evening gowns, home furnishings and bedding.

MARKETING OPPORTUNITIES

lyocell process If processed with a lyocell process.

PEFC-certified Must be verified, and can be claimed on POS items at retail.

FSC-certified Must be verified, and can be claimed on POS items at retail.

Lenzing Viscose® If verified and used.

OEKO-TEK® Standard 100 certified If verified and used.

INNOVATION OPPORTUNITIES

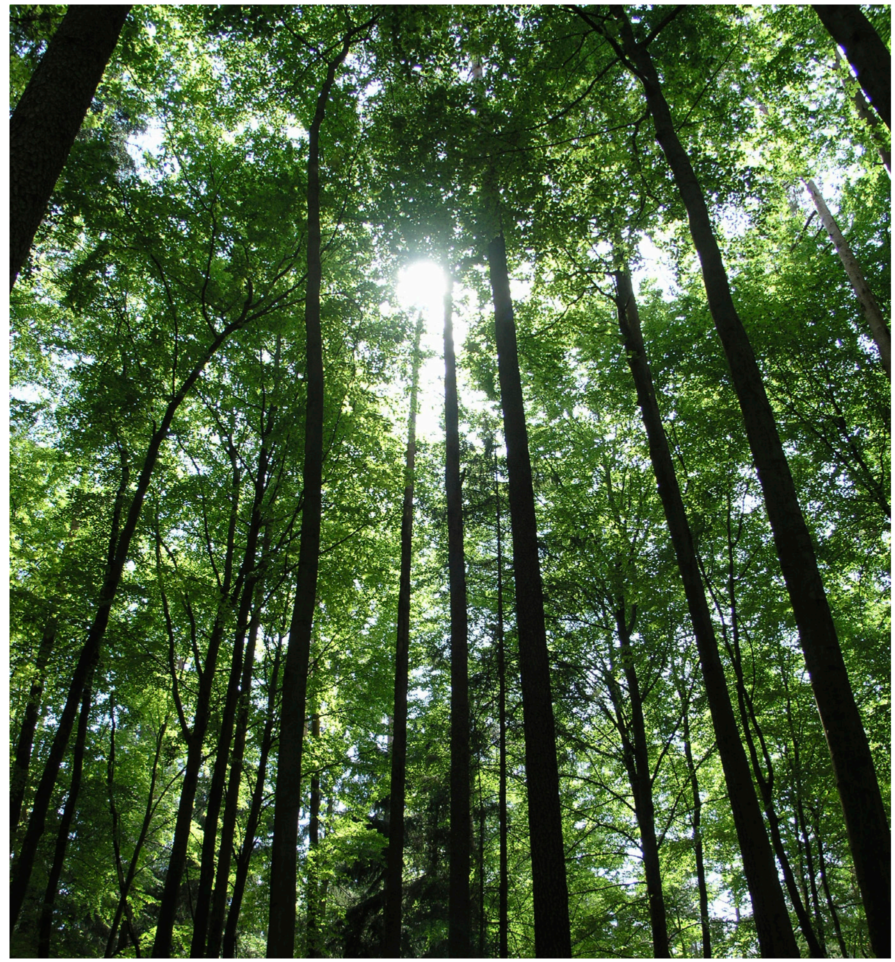
1. Shift to existing environmentally beneficial fabrics when possible. These fabrics include fabric derived from organic cotton, recycled fabrics, hemp, flax, and dissolving pulp from bamboo and eucalyptus plantations that are PEFC or FSC-certified.

2. Use wood pulp from PEFC and FSC-certified plantations, and produce the fabric with lyocell process. Communicate the difference between the viscose and lyocell processes to consumers on your website and hangtags.

3. Encouraging handwashing on the hangtag and labeling/POS would influence the consumer to take an active role in reducing environmental impacts of viscose at the consumer washing stage.

1. www.swicofil.com/products/200viscose.html
2. www.canopy.org/index.php
3. oecotextiles.wordpress.com/2009/08/19/348/
4. www.eksoy.com/PDF/VISCOSE%20AND%20BAMBOO.pdf
5. textilefashionstudy.com/process-flow-chart-of-viscose-fabric-dyeing/
6. textilelearner.blogspot.com/2012/09/100-viscose-fabric-dyeing-method-dyeing.html
7. ftc.gov/opa/2009/08/bamboo.shtm
8. lenzinginnovation.lenzing.com/fileadmin/template/pdf/Texworld_USA_2012/16_01_2012_2_PM_Lenzing_Edelweiss.pdf
9. www.lenzing.com/sites/botanicprinciples/website/index.htm
10. www.OEKO-TEK.com/media/downloads/Factsheet_OETS_100_EN.pdf

USE WOOD PULP FROM PEFC AND FSC-CERTIFIED PLANTATIONS, AND PRODUCE THE FABRIC WITH LYOCELL PROCESS.



BIOPOLYMER FIBRES

Sustainability in textiles and fashion requires working within the planet's capacity to generate the raw materials used for fibres, and to absorb the waste produced by industrial processes and garment disposal.

For fibres based on oil (polyesters and nylons) there is an imbalance between the rate of extraction of the raw material and the speed with which it can be regenerated (approximately one million years for oil). Oil-based fibres also persist and accumulate in the environment, since microorganisms lack the enzymes necessary to break synthetic fibres down into non-toxic components in a relatively short period of time. For these reasons, synthetic fibres are considered non-renewable and non-biodegradable.

BIOPOLYMER FIBRES ARE A PROACTIVE AND ECOSYSTEM-INSPIRED RESPONSE TO THE IMBALANCE BETWEEN THE RATE OF EXTRACTION AND REPLENISHMENT OF OIL AND THE RISING LEVELS OF TEXTILE AND GARMENT WASTE IN LANDFILLS.

For biopolymer production, fast-growing and replenishable agricultural crops such as corn, sugar, castor bean, etc., replace oil-based feedstock. Since plant-based fibres degrade into simpler particles more readily at the end of life than do oil-based ones, biopolymers may offer the promise of biodegradability.

POLYLACTIDE (PLA)

Polyactide (PLA) is mainly made from sugars derived from corn, though any abundantly available sugar, such as wheat, sugar beets or sugarcane could also be used. PLA is a new class of polymer that is biodegradable under optimum conditions. Ingeo from NatureWorks LLC is a readily available brand name of PLA.[1]

BIOPOLYMER FIBRE

BENEFITS

Polylactide (PLA) is a fibre-forming substance that is composed of at least 85% by weight of lactic acid ester units derived from naturally occurring sugars.[2] It can be derived from sugars found in corn, sugar beets, wheat, rice potatoes … basically any starchy plant can be used.[3] It is then melt-spun in a process similar to conventional polyester.[3]

Polylactide reduces the use of petroleum, which is a non-renewable resource, and associated greenhouse gas emissions.

Polylactide has excellent resiliency, outstanding crimp retention and good wicking ability. It has good thermal insulation, breathability, high UV protection and excellent hand and drape.[2] PLA has natural resistance to staining, low odour retention, and can be machine-washed and dried, with no need to iron.

Polylactide is fully biodegradable (as long as component parts of the garment are also made from PLA), and optimum composting conditions are present.

The use of PLA could allow Europe to reduce its reliance on foreign sources of fossil fuels. Europe meets its oil consumption/needs by importing from foreign sources such as the Russian Federation, Africa and the Midlde East (only 14% comes from Europe).[4, 5]

POLYLACTIDE CAN BE DERIVED FROM SUGARS FOUND IN CORN, SUGAR BEETS, WHEAT, RICE, POTATOES ... BASICALLY ANY STARCHY PLANT CAN BE USED. IT IS THEN MELT SPUN IN A PROCESS SIMILAR TO CONVENTIONAL POLYESTER.

POTENTIAL IMPACTS

PROCESSING

Land degradation from intensive agriculture to meet human demands for food, fibre and fuel have resulted in land degradation of over 25% of the world's agricultural land, pastures, woodlands and forest.[6]

Polylactide is relatively new on the market and has to go through further development to improve its performance characteristics, price and scalability. For example, heat setting cannot always be performed properly, and consequently PLA fabric has a low melting point, which can affect dimensional stability during storage, transportation, dyeing, ironing, transfer printing, etc.[7]

END OF USE

Polylactide is **biodegradable**, but only under optimum conditions. PLA will not biodegrade in landfills. It requires a balance of oxygen, moisture, aeration and steady temperatures of 49-60 °C—a balance that is typically found in industrial composting facilities. Home compost heaps do not provide the required combination of temperature and humidity to trigger decomposition.[7]

Furthermore, PLA cannot go into the regular recycling bin and can contaminate a batch of PET. There is currently no standard system for differentiating PLA plastics.

When used in combination with non-renewables, PLA cannot be claimed as biodegradable.

MORE INFO APPENDIX: BIODEGRADABILITY

POLYLACTIDE (PLA) IS BIODEGRADABLE, BUT ONLY UNDER OPTIMUM CONDITIONS. PLA WILL NOT BIODEGRADE IN LANDFILLS.

OPTIMIZE SUSTAINABILITY BENEFITS

- Connect to or develop infrastructure to collect and process compostable fibres.
- Label garments for consumers and identify composting routes for biodegradable fibres, to ensure they remain separate from degradable and non-degradable synthetics.
- Use non-genetically modified, organically grown feedstock.
- Check colour matching, as dark colours can be difficult to achieve.
- Ensure requirements are met in terms of light and colour fastness.

AVAILABILITY

Ingeo, a brand name for polylactide, is readily available from NatureWorks LLC.

There are also sources in Belgium, Italy and the United Kingdom producing polylactide for non-wovens.

APPLICATIONS

Pillows, comforters, mattress pads, performance activewear, fashion apparel, outdoor furniture and non-wovens, such as diapers.

MARKETING OPPORTUNITIES

XX% bio-based content Confirm the percentage of bio-based content for accurate labeling

biodegradable In order for polylactide to successfully biodegrade, it must be disposed of into a composting facility. Not only do customers have to dispose of PLA properly, but the proper infrastructure must be in place in order to process it. Can not claim "biodegradable" if these areas have not been investigated or communicated. To be labeled as biodegradable, documentation is required to substantiate that the product can completely break down into non-toxic material.

INNOVATION OPPORTUNITIES

1. Design completely biodegradable garments where all fibres and component parts compost fully and safely.

2. Partner with composting facilities to guarantee effectiveness of composting ability.

3. Design garments and products with reusable trims, and a biodegradable body. Design the product so that non-biodegradable trims, tags, buttons, etc., can be easily separated from the main body of the product at the end of its useful life. Create collection systems for the products. Collect products and separate trims from biodegradable PLA body. Distribute PLA to compost facility, and reuse trims.

4. Communicate to customers proper route of disposal.

5. Get your product Cradle to Cradle Certified. The Cradle to Cradle Certified™ Product Standard is a multi-attribute, continuous improvement methodology that provides a path to manufacturing healthy and sustainable products. The Standard rewards achievement in five categories and at five levels of certification. An accredited assessor will help to assess and optimize your product.

1. www.natureworksllc.com
2. Freinkel, Susan. PLASTIC A Toxic Love Story. New York: Houghton Mifflin Harcourt, 2011.
3. Cohen, Allen and Ingrid Johnson. Fabric Science. New York: Fairchild Books, 2010.
4. "Monthly and cumulated Crude Oil Imports (volumes and prices) by EU and non EU country," 2012.
5. ec.europa.eu/energy/observatory/oil/import_export_en.htm
6. Doran, "International Workshop on Assessing the Sustainability of Bio-Based Products," 2003.

PROCESSING

These days garments are almost always dyed or printed, bleached or washed in order to give them a more desirable, aged or unique look.

At the start of the design process, consider how these garment processes could impact the environment. Use this Toolkit to develop sustainability innovations for garment processing that not only are unique and innovative, but also improve the quality of the world around us.

BLEACHING

Bleaching is the process of removing colour and is typically used to whiten cloth made from natural fibres where naturally occurring pigments are present.

PROCESSING

Bleaching is often used in conjunction with other cleaning processes such as desizing or scouring as preparatory steps for subsequent dyeing, printing, and/or finishing processes, since most of these processes work best on clean, white fabric. Fabric or garments can also be bleached, finished and sold white.

Bleach is also effective at removing colour from previously dyed/printed products, and is commonly applied in industrial laundries to achieve "vintage" or "faded" looks (e.g., bleaching of indigo-dyed denim garments).

Bleaching can be vital to reducing the ecological impact profile of a garment—it can ensure proper first time dyeing and avoid re-dyeing, which is resource-intensive and pollutive.[1]

TYPES OF BLEACHING PROCESSES

HYDROGEN PEROXIDE

About 90% of fabric bleaching carried out prior to dyeing/printing is performed using hydrogen peroxide, a relatively safe chemical that decomposes into water and oxygen. Hydrogen peroxide is economical and readily available.

Potential Impacts:

Hydrogen peroxide bleaching requires high temperatures (above 60°C), which makes it an energy-intensive process. In addition, hydrogen peroxide is relatively unstable and requires chemical stabilizers and additional additives to optimize the bleaching process. These can be pollutive if left untreated and discharged into wastewater.[1]

CHLORINE DERIVATIVES

About 90% of garment bleaching, used mainly for fading pre-dyed and pre-printed items, is performed using chlorine derivatives (usually sodium or calcium hypochlorite) or potassium permanganate (also known as PP).

Hypochlorite is reactive enough to work well at cooler temperatures and breaks down into table salt, oxygen, and water. Like hypochlorite, potassium permanganate is a strong oxidizing agent. Potassium permanganate is particularly suitable for selective, or precision, applications (e.g., spraying or sponging) to achieve patterned effects, since its deep purple colour makes it easy for the operator to see in real time and to visually track its application to the garment.

Potential Impacts

If hypochlorite is exposed to organic material before it breaks down, it can react with that material to form halogenated organic compounds (organochlorines). Halogenated organic compounds are persistent, toxic compounds, may **bioaccumulate** in the food chain, are known **teratogens/mutagens** and suspected human **carcinogens**, and may cause reproductive harm. Hypochlorite can also react with acids, ammonia and even dirt particles to form toxic gases.

Due to its highly toxic nature, personal protective equipment is required for workers handling PP.

Besides stripping colour from the garments to which they are applied, chlorine derivatives and other oxidizing agents also attack and weaken the fibre and are particularly destructive to elastic fibre (spandex) in stretch fabrics, rendering the finished garment more fragile and susceptible to being discarded by the consumer more quickly.

ALTERNATIVE TECHNOLOGIES

OZONE

Ozone gas is comprised of three oxygen atoms (03) and is a much more powerful oxidizing agent than chlorine. It is very effective at fading pre-dyed/pre-printed fabrics and garments, can be performed at lower temperatures than hydrogen peroxide, and uses no water at all. In addition, ozone is completely biodegradable, as it reverts rapidly back to oxygen (02), leaving no chemical residue. However, the ozone bleaching process still requires an alkali addition to swell the fibre and remove motes from cotton, and scouring and sequestering agents still need to be used.[2] Additionally, ozone is highly unstable and cannot be stored. It must therefore be generated on-site as needed, meaning that any manufacturing facility intending to use ozone as a bleaching agent must invest in ozone generating equipment.

LACCASE

Laccase is an enzyme that has proven effective at decolourizing or fading pre-dyed/pre-printed apparel products. Generally speaking, enzymes are considered low impact because they are biodegradable (no waste products) and typically work well at low temperatures, thereby minimizing energy consumption. A small amount of enzyme often saves significant amounts of water, energy and chemicals used in bleaching.[3] For example, Gentle Power Bleach™, a bleaching technology developed by Huntsman Textile Effects and DuPont, is an enzyme-based peroxide process that enables bleaching of textiles at 65°C using a neutral pH. The company claims that using Gentle Power Bleach™ lowers treatment and rinsing temperatures and requires fewer rinse baths, resulting in significant water and energy consumption savings and eliminating the need for caustic soda altogether.[4]

Laccase's effectiveness varies depending on the specific dye-stuff(s) used to dye/print the fabric or garment, but it works quite well on indigo-dyed denim products. Moreover, bleaching with laccase affects only the dyestuff, and will not weaken the fibre or fabric. However, enzymes are often more expensive than chemical options for bleaching, and some of the more popular denim shades may be difficult to achieve through enzyme technologies. For example, heavily faded denim effects cannot be replicated using laccase, and laccase often imparts a grey cast to indigo-dyed fabrics.

OPTIMIZE SUSTAINABILITY BENEFITS

OPPORTUNITY	CONSIDERATIONS
Look for design opportunities to avoid bleaching. Darker, duller shades may not require bleaching prior to dyeing/finishing.	Lighter, brighter shades do need to be chlorine bleached before dyeing.
Promote suppliers who use ozone bleaching processes. **Promote the aesthetic of ozone bleach effects.**	• Ozone has limited availability, and is relatively expensive since it requires investment in an ozone generator. • Ozone produces a different aesthetic than chlorine derivative or permanganate bleaching.
Promote suppliers who use enzyme process bleaches. **Promote the aesthetic of enzyme bleach effects.**	• Enzyme produces a different aesthetic than chlorine derivative or permanganate bleaching.
Promote suppliers who use low-temperature peroxide bleach processes, such as pad-batch systems.	• Pad-batch bleaching is much slower than high-temperature peroxide bleaching, and requires significant floor space to store batches for long periods of time.
Avoid chlorine bleaching if possible. **For fabric bleaching prior to dyeing/finishing, do not accept chlorine-derivative bleaches when peroxide will suffice.**	• Peroxide might be slightly more expensive than chlorine-derivative bleaches, but they are less toxic.
Promote proper wastewater treatment.	• Develop standards for laundries and/or fabric dye-houses.

AVAILABILITY

Hydrogen peroxide is widely available globally.

Chlorine derivatives and potassium permanganate are used by the majority of garment laundries to fade pre-dyed/pre-printed garments.

Ozone is relatively expensive and the equipment is not yet widely available.[1]

Enzyme bleaching technologies are readily available globally.

APPLICATIONS

Not all fabrics require bleaching before they are dyed and finished. As a rule, only fabrics which contain naturally-occurring pigments (such as hemp and linen) require bleaching with chlorine. Cotton fibre is naturally cream coloured and hydrogen peroxide bleaches will suffice in preparing cotton fabrics for dye. Wool and silk fibres yellow with the use of chlorine bleaches. Intended shade is another factor that determines the necessity of bleaching. Many darker, duller shades (dark browns, dark navys, black, etc.) are relatively easy to achieve on unbleached substrates, whereas lighter and brighter shades require a cleaner base.

Hydrogen peroxide, ozone and laccase bleaches can be effective substitutes for chlorine derivates and potassium permanganate depending on the desired degree of fading, the desired shade/cast, the specific colourants involved, the equipment available, and the application technique(s) employed.

MARKETING OPPORTUNITIES

- Gallons of water per jean saved when ozone bleaching is used.
- **non-chlorine bleached** If alternative bleach is used.
- Providing educational information on the corporate/brand website (perhaps in the same place as the CSR reports) could detail information about alternatives used for garment bleaching.

INNOVATION OPPORTUNITIES

- Promote suppliers who use ozone and laccase (or other enzyme) bleaches. Promote the process on POS items. Look for opportunities to promote the different aesthetic and shades/casts common to ozone/laccase fading and build a collection around the eco-story.
- Creative exploration of the effects of different types of bleaching on different fabrics could yield a white-on-white story, typically a great retail seller for summer. The garments would become a vehicle for communicating the different bleaching options and their different ecological impact/benefit.
- Showcase your company's alternative bleaching methods on a plain T-shirt.
- Develop graphic symbols for hydrogen peroxide, ozone, laccase/enzyme, etc., to communicate with the customer.

1. Grose, Lynda and Kate Fletcher.Fashion & Sustainablity: Design for Change. London: Laurence King Publishing Ltd, 2012.
2. Cotton Incorporated (2013) e-mail conversation March, 2013.
3. Nielsen, P H, Kuilderd, H, Zhou W, Lu X, (2009) 'Enzyme Biotechnology for Sustainable Textiles (hydroxyalkanoates) (PHA) and other fibres, in Sustainable Textiles: Lifecycle and environmental impacts by R.S. Blackburn (Ed.) Woodhead Publishing, Cambridge, p113-138.

DYEING & PRINTING

The goal of adding colour to a textile substrate is to produce an appealing, level, fast colour on a product at a reasonable cost with good performance and minimal environmental impact.

PROCESSING

Colour is a critically important part of a fabric or garment, and one of the single most important factors in the appeal and marketability of an apparel product, particularly during the "interest" phase of the consumer purchasing decision. An inappropriate or unattractive colour may make a garment unmarketable no matter what the quality of the fibre, the yarn, the weave or knit, or the finish. Conversely, a poor-quality fabric may achieve big seller status purely because of its colour. Aside from its attractiveness, colour permanence (i.e., fastness) is important; most problems that consumers have with textile and apparel products are associated with colour fading, bleeding or colour staining (crocking).

At one time, colourants were limited to natural dyes and pigments obtained from plants, insects and minerals. The first synthetic dye was developed in 1856 and by the early 20th century, a wide range of synthetic dyes were readily available. Today, the textile and apparel industry uses well over 1 million tonnes of colourant annually, almost all of which is manufactured synthetically.

Adding colour to a textile substrate is a complex process. Slight differences in fabric caused by minor irregularities in fibre, yarn, fabric, or finishing can result in obvious colour variations in finished products. Fibre chemistry also plays an important role. A match between the chemistry of the colourant and that of the fibre is necessary in order for the colour to be permanent. In addition, during use, any textile may be exposed to a wide variety of potential colour degradants such as detergent, perspiration, dry-cleaning solvents, sunlight, makeup, etc. To achieve a durable colour, the colourant must be attached to or trapped within the fibre by using a combination of heat, pressure and chemicals. Fibre crystallinity, chemical finishes, and fabric and yarn structure are all factors that influence the success of dyeing and printing.

OVERVIEW OF ENVIRONMENTAL CONCERNS IN DYEING & PRINTING

- **Formaldehyde** common ingredient of dispersing agents (for vat, sulfur, and disperse dyes), printing pastes (ingredient of resins added to promote cross-linking between binders and fibres), and colourant fixatives
- **Heavy metals** found in dye-stuffs, dyeing auxiliary chemicals and print pastes (as PVC stabilizers); often an unintended contaminant found in numerous chemicals
- **PVC and phthalates** used in plastisol printing pastes
- **Residual colour in wastewater** due to poor exhaustion and/or fixation of colourants
- **Salt** used to promote exhaustion of reactive and direct dyes onto cotton substrates
- **Volatile organic compounds (VOCs)** in print pastes (particularly solvent-based)
- **High biological oxygen demand (BOD) or chemical oxygen demand (COD)** caused by substances in the wastewater after dyeing and finishing. BOD and COD create environments that are hostile to aquatic plants and animals.

SYNTHETIC COLOURANTS

Synthetic colourants are man-made and cost less than natural colourants, are offered in a diverse range of colours, are more colour-fast and easy to apply.

Chromophores are an essential part of the colourant's chemical structure, and are partly responsible for a chemical's ability to project colour. Chromophores are limited in terms of the fibres upon which they can be used (i.e., limited to certain dye classes), the number of hues possible, the intensity of colour required, and/or cost.

More than 50% of all commercial colourants contain one or more functional chromophores known to the azo group. Many dye classes make use of azo groups (e.g., direct, azoic, reactive, acid, basic), as do some pigments, so their presence is not limited to any particular textile fibre or substrate. Under certain conditions, they can break down to form aromatic amines, which can then be released from the fabric or garment and may be carcinogenic. The use of certain colourants that contain azo groups— mostly those that can release higher concentrations of amines— is forbidden in many parts of the world. This includes around a dozen acid dyes (normally used with nylon and wool) and numerous direct dyes (used with cellulosic fibres).

Anthraquinone is the second most common chromophore. Anthraquinone chromophores are found in vat, reactive, disperse, acid dyes, and in some pigments, so they can be used on cellulosic fibres such as cotton or rayon and on synthetic fibres such as polyester and nylon. Anthraquinone colourants are often brighter than their azo counterparts, but are limited in terms of shade depth.

Potential Impacts

Chemicals used in textile and garment dyeing and printing are developed to be resistant to environmental influences. This durability sometimes limits the biodegradability of colourants and makes them difficult to remove from wastewater generated by dyeing or printing processes. Conventional treatments tend to transfer waste from one place to another. For example, solids extracted from wastewater are sometimes hazardous and are disposed into special landfills, where they can cause groundwater contamination, gas formation and noxious odours.

Certain types of dyes are suspected **carcinogens** and **mutagens**, while other disperse dyes are known to have a sensitizing effect on skin and should be avoided. Turquoise blue and greens contain metals, such as copper and nickel, as part of the dye molecule. Metals can cause toxicity in aquatic environments. Metal-containing colourants can be replaced with colourants that do not contain metals or contain lower metal content, though this is sometimes at the expense of colourfastness. These dyes are carcinogenic or mutagenic colourants and should be completely avoided: CI Basic Red 9, CI Disperse Blue 1, CI Acid Red 26, CI Basic Violet 14, CI Disperse Orange 11, CI Direct Black 38, CI Direct Blue 6, CI Direct Red 28, and CI Disperse Yellow 3.

NATURAL COLOURANTS

Natural colourants are produced or extracted from plants, arthropods and marine invertebrates (e.g., sea urchins and starfish), algae, bacteria, fungi, and minerals. Sources for natural colourants include cochineal, mollusks, roots, berries, bark, lichen, carrots, artichokes and other natural matter.

In order to achieve acceptable colourfastness, mordants are almost always necessary to properly fix natural colourants to textile and apparel substrates. Mordants increase colourfastness by combining with both the colourant molecule and the fibre molecule. The most commonly used mordants for natural dyes are chromium, aluminum, iron, copper, tin and other heavy metal salts.

A major challenge with natural colourants is producing natural colourants in large quantities, at a reasonable cost, and to achieve comparable colourfastness.

Obtaining a full palette of colours using natural colourants remains a challenge, as does repeatability, light fastness and durability to wear. Furthermore, in production it's extremely difficult to produce the same natural dye shade twice, even when using exactly the same dyeing technique and procedure. For these reasons, natural dyes remain niche in the commercial fashion world, and are well suited to the "slow fashion" movement, which emphasizes locality, difference and diversity, though new technologies may at some point bring natural dyes to wider economic viability.

SOURCES FOR NATURAL COLOURANTS INCLUDE SUNFLOWERS, COCHINEAL, MOLLUSKS, ROOTS, BERRIES, BARK, LICHEN, CARROTS, ARTICHOKES AND OTHER NATURAL MATTER.

Potential Impacts

It requires approximately 1 pound of fresh plant to produce the colouring power of one gram of synthetic colourant. In a world of increasing human population and declining natural resources, land use for food vs. colouring material will be hotly contested.

PRINTING: APPLICATION OF COLOUR

Printing is the patterned application of colour. Since the colourants and auxiliary chemicals used in printing are similar to those used in dyeing, many of the environmental concerns are shared between these processes. However, to obtain the sharply defined, precise, reproducible patterns typical in printed textiles it's necessary to use special liquids, known as pastes or inks that have a high degree of viscosity (i.e., they're in a "gel" state). The printing ink, which typically includes colourants, binders, softeners, thickeners and other auxiliary chemicals, can be directly applied to the substrate using mesh screens, engraved rollers, ink-jet printers and can be indirectly applied to the substrate using pre-printed transfer paper.

The two main types of printing inks are pigmented emulsions and plastisol inks.

EMULSION INKS

Emulsion inks are used mainly for direct printing of fabrics and are typically based on aqueous dispersions (i.e., water-based) of a binder and cross-linking agent. Emulsion inks can be solvent-based, although their use is rare in textile and garment printing.

Potential Impacts

Solvent-based inks have high volatile organic content (aliphatic, aromatic and oxygenated organic solvents), and can cause problems with air pollution and waste disposal.

PLASTISOL INKS

Plastisol inks are primarily used for direct and indirect (transfer) printing of garments and are typically vinyl resin (**PVC**) dispersed in plasticizer. In garment printing, PVC serves as a binder that melts into, or fuses with, the garment while bearing the solid pigment. Plastisol inks contain plasticizers, which soften the naturally rigid PVC to give it the flexibility to keep from cracking. When used as a transfer, the plastisol ink is screen-printed onto a release paper and cured to a dry film, which is then stored until being transferred onto a garment using a heat transfer process.

Potential Impacts

Plastisols do not biodegrade. One byproduct of their production (and of disposal via incineration) is dioxin, an acutely toxic substance.

If landfilled, heavy metals sometimes used as PVC stabilizers, such as lead or cadmium, can contaminate groundwater.

Plasticizers are often phthalate esters, which may leach out of the print or may evaporate and be released during drying, either during the production process or in the home. Exposure to phthalates is known to cause adverse health effects, and several phthalates are banned by the California's Prop 65 law in the United States.

DISCHARGE (REMOVAL OF COLOUR)

Whereas printing is the patterned application of colour, discharge printing is the patterned removal of colour. In other words, the fabric or garment is dyed prior to printing (commonly known as the "ground" colour or shade), and then printed with a paste or ink containing a chemical discharge agent. The discharge agent is capable of destroying the chromophoric system of the original colourant(s) under appropriate conditions, thereby severely degrading/fading the colour or removing it altogether. Many reducing agents, oxidizing agents, acids, salts and alkalis can function as discharge agents. All colourants react differently to these agents; some are dramatically affected, while others are largely or completely resistant. If more-resistant and less-resistant colourants are combined into one dyed ground shade and then discharge printed, the area to which the agent is applied creates a shift in hue. Colourants that are resistant to the discharge agent can also be included in the print paste itself, so that they effectively "replace" the discharged colourant(s). This replacement colour is sometimes referred to as the "effect" colour.

The most common reducing agents used in discharge printing are metal salts of formaldehyde-sulphoxylic acid, such as zinc, sodium or calcium formaldehyde-sulphoxylate. An alternative, but less frequently used agent, is thiourea dioxide.

ZINC FORMALDEHYDE-SULPHOXYLATE (ZFS)

Zinc formaldehyde-sulphoxylate (commonly known as ZFS) is particularly popular, because it helps to cure the acrylic binders commonly included in the discharge print paste. When combined with appropriate inks and a humectant, ZFS can be used in dry as well as wet or moist heat conditions.

Potential Impacts

Releases formaldehyde during the discharge reaction process. Formaldehyde is retained in the fabric. Formaldehyde is a toxic air pollutant, a volatile organic compound, is allergenic and/or carcinogenic in certain conditions, and is heavily regulated.

THIOUREA DIOXIDE

Unlike formaldehyde-sulphoxylates, thiourea dioxide neither contains nor releases formaldehyde. However, its effectiveness in discharging colour is limited to a narrower range of colourants and its effect is noticeably weaker than formaldehyde-sulphoxylates. Thiourea dioxide also requires steaming and thorough washing after the discharge print paste is applied.

Potential Impacts

Requires steaming and thorough washing after the discharge print paste is applied.

DYEING: REACTIVE AND DIRECTIVE DYES

When reactive or direct dyes are used to dye cotton, the use of salt—usually sodium chloride or sodium sulfate (also known as Glauber's salt)—is necessary to promote exhaustion (uptake and fastness) of the dye onto the cotton substrate. Sodium chloride is less expensive and contains more sodium per unit mass than Glauber's salt, so less salt is needed in the dye solution. However, Glauber's salt is less corrosive (particularly to dyeing machines) and produces brighter shades when used with some classes of dyes. In general, reactive dyes require 5-10 times more salt than direct dyes, and dark shades require 5-10 times more salt than light shades.

In addition to dye class and shade depth considerations, the amount of salt required in dyeing cloth is dependent upon the volume of the dye bath solution in relation to the mass of the material being dyed. This "liquor ratio" can vary widely depending on the dyeing equipment used. Some garment dyeing machines require as much as 400 gallons of dyebath for every pound of material dyed, whereas the commonly used jet dyeing systems require 80 gallons or less. In other words, the former would require five times more salt in the dying process than the latter.

Potential Impacts

Salt use in textile dyeing is a serious environmental issue, since it is used in such large quantities and is a major source of aquatic toxicity in wastewater. Moreover, the removal of salt from wastewater is extremely difficult and expensive using current treatment methods.

Low- or no-salt developments are therefore of great interest in the chemical dye industry. Direct dyes use less salt than reactive dyes, but their attraction to cotton is relatively weak, and they are often treated with special fixing agents to improve colourfastness. Cationic fixing agents (usually quaternary ammonium compounds) are commonly used to improve wash fastness, and copper sulfate is sometimes used to improve light fastness. Both are major concerns in terms of aquatic toxicity.

REDUCE ENVIRONMENAL IMPACTS OF DYEING & PRINTING

NATURALLY COLOURED COTTON

Naturally coloured cotton has existed for more than 5000 years. Naturally coloured cotton has pigmentation in the center, or lumen, of the fibre and the colour depth and shade varies with growing conditions, location and climatic factors. Generally speaking, natural colours range from shades of cream and tan to tones of brown, red and green, although purple, mauve, grey and black cottons are theoretically also possible.

Over the past twenty years, considerable work has been done to cross breed coloured cotton fibres to both expand the range of available colours and to improve the fibre length and quality. As a rule, naturally coloured cotton suffers from lower agricultural yields, making it economically challenging to produce, and therefore expensive to the mills and manufacturers. Brown fibre is typically 2-3 times the cost of white cotton fibres, and green fibre approximately 4 times the cost of white fibres. Coloured cotton fibre also lacks important quality characteristics such as fineness, length and strength, and requires special handling through ginning and spinning, since the colour can catch on equipment and contaminate the batches of white cotton fibre most commonly processed through the facility.

For these reasons, naturally coloured cotton fibres are usually blended with white cotton to improve quality, facilitate processing and reduce costs. Though blending reduces the colour intensity of the end product, washing the yarn or laundering the product in alkaline solution can enrich hues. The strength of 100% coloured cotton can also be improved by plying several ends of yarns together (2 or 3 ply), though this increases cost. Coloured cotton yarns can also be plied with white cotton yarns to bring cost down. Coloured cotton fibre properties can differ profoundly by colour and are largely dictated by the cultivation practices by the type of seed used. In terms of colourfastness, brown and beige cottons generally outperform greens.

"RIGHT-FIRST-TIME" DYEING

Without question, the most effective pollution prevention practice in colouring cloth is "right-first-time" dyeing. Corrective measures such as reworks, re-dyes, stripping, shade adjustments, top-ups or "adds" are all chemically intensive and contribute significantly to pollution, since each corrective action increases colourant and/or chemical and water use.

SPUN DYEING

Synthetic fibres can be coloured by introducing pigments or dyes into the polymer melt prior to extrusion. Spun dyeing reduces water and pollution associated traditional dyeing, and can also produce favorable chartacertisitcs, such as such as uniform colouration, level shade, a high degree of light fastness, relatively low cost and cleanliness.

AUXILIARY CHEMICALS

Auxiliary chemicals can be selected to minimize or reduce the environmental impact of dyeing and printing processes. For example, acetic acid, which has a relatively **high biological oxygen demand (BOD)**, is used in a variety of textile and garment processes for pH adjustment. Formic acid, which has a much lower BOD, or dilute mineral acids, which have no BOD, can sometimes be substituted for acetic acid.

In addition to chemical substitution, harmful auxiliary chemicals can sometimes be completely avoided by changing operating conditions. For example, "carriers" are organic chemicals that are often used as dyeing assistants when dyeing hydrophobic synthetic fibres such as polyester. In essence, carriers "open" the synthetic fibre, thereby increasing the rate of dyeing. The most common carriers are chlorinated benzenes and biphenyl. As a rule, carriers are extremely volatile and are also toxic, and they contribute significantly to toxic air pollution. But if dyeing takes place at a high enough temperature, carriers are unnecessary. In order to reach the required temperature (at least 129° C), a pressurized dyeing vessel is necessary. Many dyeing facilities have pressurized dyeing machines, but not all.

1 http://www.fibre2fashion.com

LOW-LIQUOR-RATIO DYEING

A typical dye bath comprises salt, acids and alkalis, lubricants, and dispersing agents, all of which can contribute to pollution. These chemicals are measured in proportion to the volume of water used, and so lower volume dye baths greatly reduce chemical use and disposal in wastewater. Lower volume dye baths also require less energy for heating. Standard liquor ratios range from 10:1 to 15:1 for many exhaust dyeing operations. Low- liquor-ratio machines are capable of dyeing at liquor ratios closer to 5:1, with some as low as 3:1. Some dye systems can operate effectively at room temperature, eliminating the need for heating altogether. It's important to note that low-liquor-ratio dyeing often limits the choice of dye class used (i.e., to more water-soluble dyes), and that existing equipment cannot normally be "retrofitted" to make it operate at lower liquor ratios; investment in new equipment is usually necessary.

DYEBATH REUSE

Dyebath reuse is the process by which exhausted hot dye-baths are analyzed for residual colourant concentrations, replenished and, rather than being dispelled as wastewater, are reused to dye further batches of fabric. Dye-bath reuse requires that colourants undergo minimal change during the dyeing process. Direct, disperse, acid or basic dyes are therefore best for reuse applications. Dye-bath reuse carries a greater risk of shade variation, because impurities can build up and decrease the reliability of the process over the longer term. Capital is also required to purchase and install the appropriate infrastructure (e.g., holding tanks, pumps) to effectively reuse dye baths. When properly controlled, some dyebaths can be reused for 5-25 cycles.

PAD-BATCH DYEING

Pad-batch dyeing is a cold dyeing method mainly used for dyeing cellulosics (100% cotton and polyester/cotton blends) and can result in significant reductions in pollution and water and energy consumption (50-80% water and energy savings are common). No salt or chemical auxiliaries are necessary and the colourant exhaustion is much higher (which means less colour released into the wastewater). Moreover, quality is often more consistent compared to other exhaust dyeing techniques. Capital outlay is also low. However, pad-batch dyeing requires significant floor space to store dyed batches for long periods of time to allow the colour to permeate the cloth. Many dye houses lack the needed space, and brands don't always have the time to accommodate the longer production processing time.

INK-JET PRINTING (ALSO KNOWN AS DIGITAL PRINTING)

Ink-jet printing is arguably the cleanest printing technology. Ink-jet printing is a noncontact printing method that works much like an office printer—droplets of colourant are propelled toward a substrate and directed to a desired spot. Colourant types that work best with ink-jet printing include reactive, vat, sulfur, and napthol dyes, although acid, basic, and disperse dyes, or even pigments, can also be used in some cases. Ink-jet printing eliminates the need for many printing auxiliary chemicals (e.g., thickener), eliminates the need for screen, squeegee, and machine cleaning (which also dramatically reduces water consumption), and reduces waste generated from strikeoffs. Though ink-jet printing machines represent a capital investment, and production speeds are still relatively slow compared to analogue printing, ink-jet can offer significant savings for short production runs.

TRANSFER PRINTING

With transfer printing, dye is printed on paper and then the paper carries the dye to secondary process where the colour is moved onto the fabric without the use of water and associated pollution associated with more typical jet dyeing systems. Transfer printing has poor fibre penetration, however.

AirDye is a propriety technology heat transfer printing technology that achieves greater penetration than traditional heat transfer printing by using a proprietary set of dyes. The AirDye process creates rich hues and achieves higher colour fastness. AirDye is suitable only for synthetics, and is readily used on polyester and nylon.[2]

2 AirDye Environmental Profile: Life Cycle Assessment (undated).

OPTIMIZE SUSTAINABILITY BENEFITS

DESIGN OPPORTUNITY	PRODUCTION OPPORTUNITY	CONSIDERATIONS
Work with mills and vendors that use low impact colourants (e.g., low COD/BOD, no metals, no formaldehyde)	Promote mills and vendors that use low impact colourants (e.g., low COD/BOD, no metals, no formaldehyde). Forbid the use of carcinogenic/mutagenic colourants, restricted azo colourants and organic solvent-based colourants.	Carcinogenic/mutagenic colourants are never acceptable.
Work with printers that offer alternatives to PVC printing (e.g., resist printing, novel techniques such as Rehance printing) and low- or no- formaldehyde, low- or no- metal plastisol variants.	Promote printers who offer PVC print alternatives and avoid phthalate plasticizers. Promote plastisol printers who offer low- or no- formaldehyde, low- or no- metal plastisol variants.	Colourfastness/durability of print may be poorer, and hand-feel may be affected
Develop discharge prints with printers who use low impact colourants and discharge agents. Avoid ZFS, heavy metals and formaldehyde. Develop with printers who offer alternatives to discharge printing (e.g., resist printers, novel techniques such as Rehance printing).	Promote discharge printers that use low impact discharge agents. Discourage the use of ZFS. Promote discharge printers who avoid heavy metals and formaldehyde.	May alter the product’s aesthetic.
Avoid carriers used to dye polyester fabrics whenever possible.	Do not use mills and vendors that use carriers when dyeing synthetics. Promote mills that use high-pressure dyeing equipment.	High pressure dye systems generally use more energy
Promote lighter cotton shades and use of direct dyes in order to minimize salt volume and waste.	Promote mills and vendors that use low- or and no-salt dyeing techniques.	If proper colourants are selected and more sophisticated equipment is used (e.g., automated dosing), salt can be reduced dramatically.

DESIGN OPPORTUNITY	PRODUCTION OPPORTUNITY	CONSIDERATIONS
Look for naturally coloured cotton design and merchandising opportunities. Emphasize and feature positive physical and colour performance properties.	Naturally coloured cotton is highly variable. Find the "good" suppliers.	Coloured cotton used in 100% produces weak yarn that can snap when making fabric. Use plied yarns in 100% or blend coloured with white fibre to improve yarn strength.
Design tonal colour range collections that are easier to work with in reuse dye bath systems.	Find and promote mills and vendors that reuse dyebaths.	
Work with mills who pad-batch dye cotton to minimize salt, water and energy use.	Find and promote ink-jet printers.	
	Promote proper wastewater treatment.	
	Promote the use of spun dyed fibres.	Spun dyed fibres reduce water and pollution associated with more traditional dyeing.
Use natural colourants on protein fibres such as silk and wool, where their colourfastness and durability is optimized. Design natural dyes to fade beautifully.		Natural colours are expensive and it can be difficult to achieve light fastness, wash fastness and long-term durability. Be prepared to accommodate different performance parameters. (colourfastness, repeatability, etc.).
Know the source and cultivation details of natural dye plants, and ensure they are sustainably grown.	Promote mills and vendors that have in-depth knowledge of natural colourants and avoid metal salt mordants.	

FINISHING

Finishing applications, such as water, stain and odour repellents and flame retardants can greatly improve the performance of garments and textiles.

These finishing applications, however, have been the source of much debate due to their bioaccumulative effects on people and the environment.

PROCESSING

WATER REPELLENTS

DWR (durable water repellent) is a coating added to fabrics at the factory. Durable water repellents (DWRs) are applied to garments and products to allow for breathability and water repellency.

Common factory-applied treatments are fluorochemicals. Certain DWRs are known to have persistent, bioaccumulative and toxicological effects on the environment.

The durable water repellent coatings used in the fashion and textile industry are currently not bio-based or biodegradable. Water repellent coatings also inhibit recyclability.

INNOVATION OPPORTUNITIES

- Investigate non-fluorochemical coatings, such as silicones, polyurethane (PU) and waxes. Although these coatings are recyclable on their own, they inhibit recyclability when applied to a dissimilar base layer. These coatings have the potential for recyclability if applied to a similar base layer.[1]

- Work with manufacturers to create bio-based or biodegradable water repellent finishes.

- Investigate recyclable waterproofing agents. Sympatex is made of completely safe polyether/ester, a combination of polyester and polyether molecules that is reportedly recyclable if applied to a similar base layer (i.e. polyester). Sympatex contains zero fluorochemicals.[2]

- Investigate durable water repellents from alternative, renewable non-toxic resources, such as castor oil.

STAIN REPELLENTS

Stain repellent finishes are used to provide stain, soil and grease release and repellency to fabrics. Fluorochemicals are the most employed repellents used for textiles.

The largest concern for chemicals used for soil and stain repellent finishes is perfluorooctanoic acid (PFOA), which is used in the manufacture of stain repellent finishes for textiles. PFOA is also produced indirectly through the gradual breakdown of fluorochemicals.[3]

PFOA is very persistent in the environment and has been found at very low levels both in the environment and in the blood of the general U.S. population.[4]

Recycling of textiles with stain repellent finishes is also very difficult.

Flurochemicals are currently being phased out by major industrial users.[5]

INNOVATION OPPORTUNITIES

- Investigate short chain fluorocarbons that do not degrade into PFOA.

- Investigate stain resistant finishes that do not involve the use of PFOA, such as finishes from DuPont.

ANTIMICROBIALS

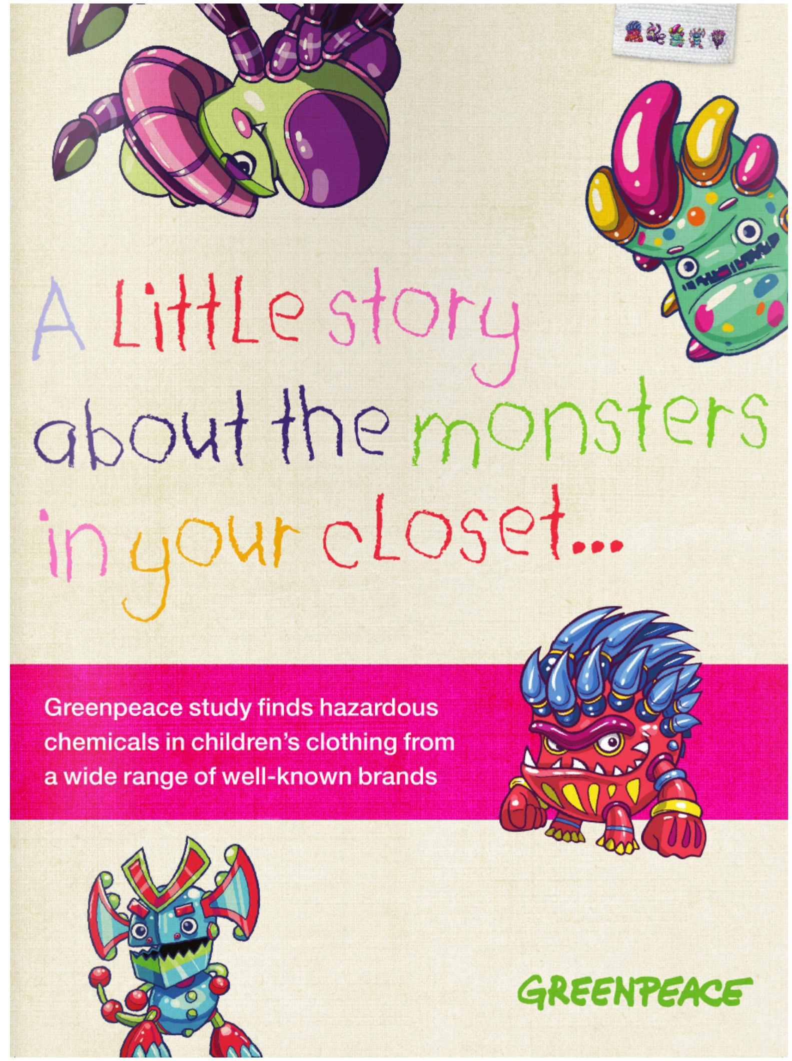
Antimicrobials are used in application such as socks, shoes and activewear to prevent odour caused by the breakdown of sweat. The use of organotins is often employed for antimicrobials on textiles. The organotins compound tributyltin (TBT) persists in the environment and builds up in the body. TBT is listed as a "priority hazardous substance" under European Union regulations and requires measures to be taken to eliminate its use.[6]

Organotins are highly toxic to aquatic species, are persistent, moderately bioaccumulative.

A recent report conducted by Greenpeace revealed organotins detected in several activewear products.[6]

INNOVATION OPPORTUNITIES

- Investigate non-toxic biodegradable alternatives to organotins.
- UV curing of chitosan as an antimicrobial finishing for textiles is a still in development, and could provide a bio-derived, non-toxic, biodegradable alternative to organotins.[7]
- Experiment with natural fibres that intrinsically repel odours, such as wool.



A RECENT REPORT CONDUCTED BY GREENPEACE FINDS HAZARDOUS CHEMICALS IN CLOTHING.

www.greenpeace.org

FLAME RETARDANTS

Common flame retardants are brominated organic compounds and are added to textiles and upholstery to delay the production of flames and prevent the spread of fire. Some flame retardants release hydrogen cyanide when set afire and can be deadlier than carbon monoxide.[8] Flame retardant chemicals can be toxic, and some are suspected carcinogens.[9]

In the European Union the use of certain flame retardants are banned or restricted.[10]

INNOVATION OPPORTUNITIES

- Investigate non-toxic flame retardant applications.
- Investigate the use of halogen-free flame retardants, such as from InnoSense LLC: www.innosense.us.
- Investigate using polyester as an alternative to textiles with a flame retardant coating. Polyester is inherently flame retardant.

1. www.dowcorning.com/content/discover/discoverchem/how-si-degrades.aspx
2. www.sympatex.com/en/membrane/224/ecology
3. www.sciencedaily.com/releases/2005/09/050920002527.htm
4. www.epa.gov/oppt/pfoa/pubs/faq.html#concerns
5. www2.dupont.com/PFOA2/en_US/QandA/index.html
6. www.greenpeace.org/eastasia/publications/reports/toxics/2014/little-story-monsters-closet/
7. www.ncbi.nlm.nih.gov/pubmed/22905533
8. www.environmentalhealthnews.org/ehs/news/2012/burning-irony
9. www.eis.uva.es/~macromol/curso07-08/ignifugos/Giulanca%20C.%20tesoro.pdf
10. www.efsa.europa.eu/en/topics/topic/bfr.htm

GARMENT WASHING

In addition to improving or softening the hand-feel of products, garment washing affects the aesthetic of the product, often by imparting a "worn in" or "aged" appearance. Garment washing has become an indispensable tool for apparel designers to manipulate garment aesthetic and to impart unique decorative effects, particularly for denim.

The umbrella terms "garment wet processing," "garment wet and dry processing," "garment finishing" or just "garment processing" can be used interchangeably to describe many different techniques, all designed to alter the garment's hand-feel or aesthetic in some fashion. "Garment washing" generally entails those specific treatments involving water and chemicals.

Dry procedures are used primarily for localized or even "patterned" abrasion effects and include techniques such as sandblasting, hand sanding, brushing, grinding, cutting (holes/patches), etc.

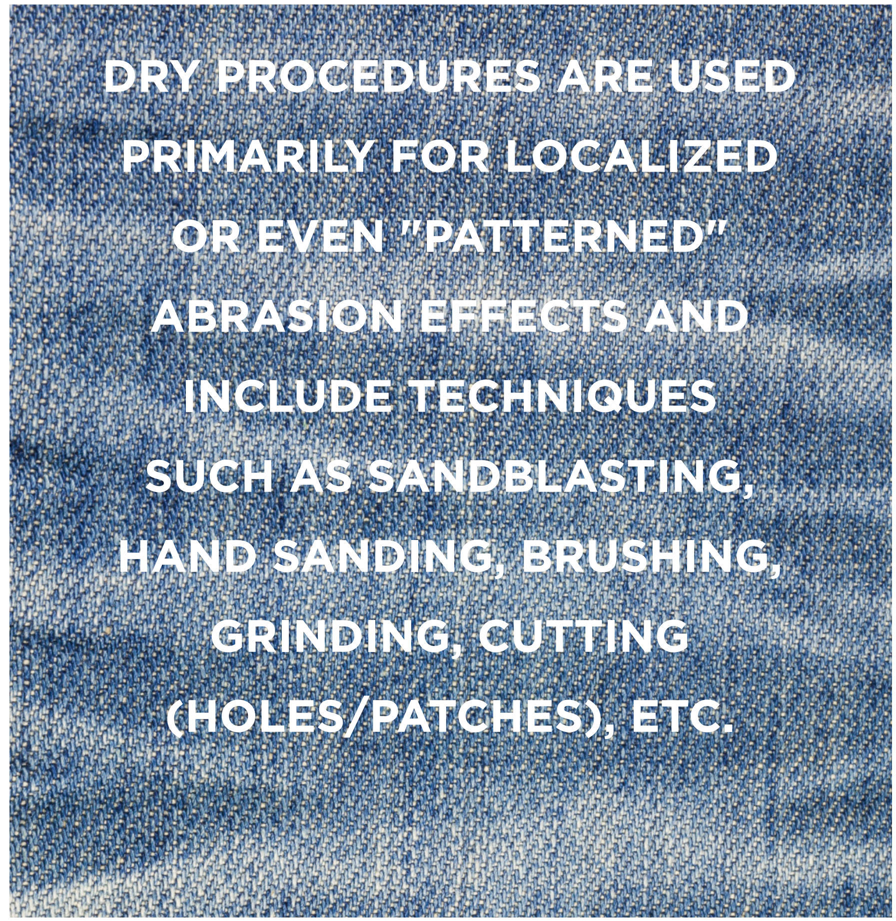
Wet garment washing processes involve the use of numerous chemicals depending on the exact nature of the process. Most wet processes are designed to abrade, decolourize, and/or soften the garments. Although the techniques are generally intended as an all-over treatment, the degree of abrasion, decolourization, and/or softening can and does vary significantly within and between garments in a typical load. For example, thick and/or more exposed areas of the garment (such as hems/seams) absorb more of the mechanical or kinetic energy during tumbling, and may therefore be more abraded and/or decolourized (faded) than flat areas. Conversely, tightly constructed areas of the garments may end up less decolourized than less-dense areas, since their ability to absorb chemicals (e.g., bleach) may be hindered.

By far, the most involved and intensive wet treatments are applied to denim products, although many of these same treatments are now applied to other woven bottoms, woven tops and even knit garments.

Two basic types of equipment are used for garment washing: 1) side-loading horizontal washers (commonly referred to as belly washers), and 2) front-loading rotary washer/extractors. There are numerous variants of each machine type.

Rotary washer/extractors, the more expensive of the two, generally provide many more options to control/optimize wet treatments, including advanced liquor ratio (water to fabric ratio) control, heating, and colourant/chemical add systems. As a rule, they provide more opportunities for waste minimization than belly washers.

After garment washing, large open-pocket tumble dryers are typically used to dry apparel. Smaller units may be heated electrically, while larger units are typically steam- or gas-heated. Modern tumble dryers have relatively sophisticated controls (e.g., moisture sensors), which help to minimize energy use.



STEPS FOR GARMENT WASHING

DESIZING/SCOURING

Woven denim products must be desized before further garment washing since they still contain sizing agents applied to the warp yarns. The most common sizing agent is starch, and amylase enzymes are commonly used to break down the starch molecules into water-soluble sugars to ease their removal.

Another common sizing agent is polyvinyl alcohol (PVA). PVA is relatively water soluble, provided it is the right "grade." No enzymes or oxidizing agents are necessary to remove water-soluble sizing agents; they can be rinsed from the garments simply by using adequate washing temperatures and times, and a good detergent. PVA can create a high chemical load in the wastewater and should be reclaimed for reuse.

In addition to sizing agents, other "top finishes" are sometimes applied to fabrics, mainly for purposes of lubrication (e.g., sewing lubricants, **sanforizing lubricants**). Garment scouring removes these top finishes, largely accomplished by rinsing with an appropriate detergent. Light scouring and desizing softens denim garments drastically.

WET ABRASION

Wet abrasion techniques are used to create a natural-looking (uneven) worn and faded effect, ranging from slightly to very uneven. Wet abrasion increases seam contrast, since thicker regions of the garment tend to abrade more readily than flatter regions. In its most basic form, wet abrasion entails tumbling wet garments in the presence of pumice stones (or an appropriate substitute). Commonly known as "stonewashing," this technique can create a wide array of effects by adjusting the amount of water or stones, the size or shape of the stones, the tumbling time, and the mass ratio of stones to garments.

Sometimes, stones are pre-soaked in an oxidative chemical solution (i.e., bleach) prior to tumbling with the garments. This increases the decolourizing potential of the stones, enabling the release of bleach to specific areas of the fabric and the garment as the stones collide. Common oxidizing agents used for this purpose include chlorine derivatives (e.g., sodium or calcium hypochlorite) and potassium permanganate. In fact, the once-popular "acid wash" was achieved by tumbling garments with stones that had been pre-soaked in potassium permanganate.

Cellulase enzymes can also be used to accelerate wet abrasion effects (by removing, or at least weakening, the surface fibre), and can reduce, or in some cases, eliminate the need for stones altogether.

Wet abrasion is usually followed by a quick rinse intended to remove any remaining loose dye-stuff and/or residual dust from stones or other abrasive materials, and to deactivate remaining cellulase enzymes if necessary.

BLEACHING

Bleaching is often used to lighten the colour of garments overall, to brighten the indigo dye used on denim products and to remove indigo dye-stuff that may have deposited on the (undyed) filling yarns during the wet abrasion process. Most garment bleaching is done with chlorine derivatives (usually sodium or calcium hypochlorite). Hypochlorite is a strong bleach, reactive enough to work well at cooler temperatures, and is effective at removing certain dye-stuffs from garments.

BRIGHTENING

Sometimes referred to as "top brightening," this garment washing technique may be utilized after bleaching to further whiten, or brighten, the decolourized areas of the garment, thereby enhancing the contrast between the light (or white) and dark areas in the fabric. This is sometimes accomplished using a milder bleaching agent (e.g., hydrogen peroxide), or may be accomplished by using an optical brightener. Optical brighteners (also known as fluorescent whitening agents or FWAs) are colourless dye-stuffs that have the ability to absorb invisible UV radiation and retransmit it as visible (white) light.

TINTING/OVER-DYEING

The application of additional colourant to garments that have already been dyed and/or printed is known as tinting or over-dyeing. If any areas of the garment are white (e.g., filling/weft yarns in denim garments), these will fully absorb the colourant, but dyed or printed areas will also pick up a degree of colour. All types of colourants (e.g., dyes, pigments, metal salts) may be used to tint fabrics, depending on the substrate. Over-dyeing with one colour changes the hue of the pre-existing colours and tends to "unify" the look of the print, often imparting a more vintage or dusty appearance to the fabric. For example, over-dyeing with a blue shade will turn browns into warm, deep grays, and will turn grays into soft blues. Over-dyeing with a red shade will turn browns into deep rust, and will turn greys into soft reds. Over-dyeing with secondary shades can result in even softer and more complex effects.

SOFTENING

The final step of most garment washing operations is softener application, which can enhance the garment's hand, drape, abrasion resistance and even tear strength. There are many different types of chemicals that can function as softeners, including sulfates and sulfonates, amines and quaternary amines, ethylene oxide derivatives, and hydrocarbon waxes. Softener selection is primarily a function of the desired hand-feel: dry (petrochemical/polyethylene), greasy (organic/fatty derivatives), or slick (silicone). Roughly one-third of the chemicals used as softeners are silicone-based. Softeners work by reducing the coefficient of friction of fibres and yarns.

POTENTIAL IMPACTS

Although dry processing techniques involve no chemicals, they do create environmental impacts, including extraction of abrasive media from natural habitats, the transport of material to the processing facility (often surprisingly long distances) and the landfilling of spent abrasive media. Dry techniques, such as sandblasting, can also involve considerable occupational health and safety hazards for operators, and proper safety precautions, such as appropriate personal protective equipment and adequate ventilation, must be in place—must not always is. Although sandblasting in Europe has been banned for decades, the practice is still abundant in Bangladesh and China, countries with a high likelihood of lack of enforcement for proper safety precautions.[1, 2]

Garment washing is a relatively water-intensive process, and may also be energy- and chemical-intensive, depending on the nature of the wash used. The environmental impacts of garment washing include the discharge of chemicals (surfactants, chelating agents, acids, alkalis, oxidizing agents, reducing agents, heavy metals, etc.) and colourants into water systems, which contributes to aquatic toxicity and/or **high biological demand (BOD)** or **chemical oxygen demand (COD)**. High BOD and COD create environments that are hostile to aquatic plants and animals and may create problems with water reuse. Any colour removed from the garments during the garment washing process is also dispelled to the wastewater and may create problems with photosynthesis for aquatic plant life.

In order to promote the permanence of colour on a textile substrate or garment, colourants and other chemicals used in textile and garment dyeing and printing are developed to be resistant to environmental influences. This durability sometimes limits the biodegradability of colourants and makes them difficult to remove from wastewater generated by dyeing or printing processes.

In terms of its environmental impact, hypochlorite used in bleaching breaks down into table salt, oxygen and water. But if hypochlorite is exposed to organic material before it breaks down, it can react with that material to form **halogenated organic compounds (organochlorines)**. Halogenated organic compounds are persistent, toxic compounds, may bioaccumulate in the food chain, are known **teratogens/mutagens** and suspected human **carcinogens**, and may cause reproductive harm.

Toxicity and biodegradability of chemicals used as softeners are primary considerations. As a rule, fatty derivatives are highly biodegradable, whereas petrochemicals are not. Silicone is highly resistant to biodegradation by microorganisms (such as those used in biological wastewater treatment), but will degrade once it is in soil (e.g., in a landfill).

TECHNIQUES TO MINIMIZE POLLUTANTS, WATER USE AND ENERGY CONSUMPTION

FABRIC SELECTION

One of the keys to reducing the environmental impact of garment washing processes is to select fabrics with desired garment hand-feel and aesthetic qualities engineered into the construction. If fabrics are physically engineered to exhibit desired qualities, the intensity (and by extension, the environmental impact) of many garment washing treatments can be minimized.

For example, the hand-feel of garments can be dramatically altered by modifying fibre diameter and cross-section, fibre length, fibre tenacity and modulus, yarn twist, yarn count, yarn hairiness, fabric stitch density, etc., thereby minimizing the need for hand-feel modification in garment washing. In many cases, only slight physical modifications are necessary (i.e., they are visually undetectable).

Similarly, the impacts of garment washing can be reduced significantly by selecting colours close to the desired final hue. Fifty percent or more of the colourant for deep shades is removed via abrasion or bleaching in garment washing. Selecting a colour closer to the desired garment shade after wash reduces the degree of decolourization (and associated energy, dye-stuff and waste) necessary.

WATER REUSE

In addition to minimizing the amount of water coming into a textile mill, water conservation can also occur after the wet processing is complete. A typical garment washing process may involve several wash cycles (e.g., desizing, wet abrasion, bleaching) as well as an assortment of rinses between cycles. This requires the garment washing machine to be drained and refilled numerous times. It's not unusual, for example, to use 35 or more gallons of water per garment during the garment washing process. In order for this water to be recycled and/or reused, it must contain little or no chlorine, and have low metal content and low salt concentration (e.g., chloride and sulfate). Alkalinity, pH and residual dyes are also of concern. Some garment washers have reduced water consumption by 50% or more by reusing process water. Some municipalities have even started marketing recycled water (e.g., water treated via reverse osmosis) to industrial customers. In fact, treated and recycled water is sometimes more consistent in terms of its impurities than potable water.

FREQUENCY OF MACHINE CLEANINGS

Total water consumption in garment washing is also affected by the frequency of machine cleaning. In general, scheduling machines to process progressively darker shades—from light to dark—minimizes the need to clean the machine between each colour batch.

LOW-LIQUOR-RATIO WASHING

One of the most important considerations, from a water and energy consumption perspective, is liquor ratio. Liquor ratio is the weight of the chemical bath (including the water) divided by the weight of the material (garments) being processed. Garment washing machines are available in a variety of sizes, and loads can vary widely depending on the nature and scale of the order. If the load size is small, and a large garment washing machine is used, the liquor ratio, the water volume and the energy used to heat that water will all be higher than necessary. Liquor ratio also affects the speed and level of fabric abrasion. In higher liquor ratio machines, garments and abrasive materials come into contact with each other less than in low-liquor-ratio circumstances. High liquor ratios therefore require more time (and energy) to achieve similar abrasion levels than low liquor ratios. As a rule, front-loading rotary washer/extractors have more flexible controls to accommodate various load sizes, enabling optimal water and energy use and minimizing waste.

PROPER CHEMICAL SELECTION

Another important element of pollution prevention is chemical selection. A wide variety of surfactants, chelating agents, oxidizing agents, reducing agents, enzymes, lubricants, colourants and other chemical types are routinely used in garment washing. Vendors generally elect chemicals based on their performance characteristics (effectiveness) and price, but must also factor environmental considerations such as toxicity, BOD, and COD into chemical selection decisions. In addition, the biodegradability of each chemical is of prime importance.

For example, alkyl phenol ethoxylates (commonly referred to as APEO), a common class of surfactant used in garment washing, are undesirable due to their poor biodegradability, their toxicity (including that of their phenolic metabolites) and their potential to act as endocrine disrupters. APEO are banned in Europe, and there are a host of wetter/scour alternatives readily available. Overseas garment washing operations may still use APEO surfactants because of their low cost and good performance characteristics. In general, chemicals and their processes should be selected to be the most benign. For some processes, enzymes can replace chemicals and include: amylases used for desizing, cellulases used for wet abrasion and laccases used for bleaching.

LASERS

Another alternative to traditional processes of decolourizing fabrics is the use of lasers. Depending on its wavelength, the laser can either: 1) be absorbed by and decompose the colourant, or 2) be absorbed by and alter the surface chemistry of the fabric. The latter technique in particular has great potential to replace traditional wet abrasion and mechanical abrasion techniques such as hand sanding because it closely emulates the results these traditional abrasion processes achieve. Lasers for this purpose are already commercially available and several are in use in laundries around the world.

LASERS CAN BE ABSORBED BY AND ALTER THE SURFACE CHEMISTRY OF THE FABRIC AND HAVE GREAT POTENTIAL TO REPLACE TRADITIONAL TECHNIQUES SUCH AS HAND SANDING.

Image source: www.janworx.com/

BLEACHING ALTERNATIVES

There are two technologies designed to replace chlorine derivative bleaches: ozone and enzyme-based processes. Ozone can be used with no water at all and is very effective at fading pre-dyed/pre-printed fabrics and garments. Laccase is an enzyme that has proven effective at decolourizing or fading pre-dyed/pre-printed apparel products. Enzymes are biodegradable (no-waste products) and typically work well at low temperatures, thereby minimizing energy consumption.

MORE INFO PART 5: BLEACHING

COMBINATION/ELIMINATION OF GARMENT WASHING PROCESSES

Another possibility for pollution prevention is the combination, or even the elimination, of specific garment washing processes. For example, denim desizing and wet abrasion have long been performed using two completely separate garment washing treatments, each with its own environmental impact. Desizing is performed using an amylase enzyme or oxidizing agent, followed by a wet abrasion treatment using stones, cellulase enzymes or both. It is sometimes possible to combine these two cycles into one, which significantly reduces process time as well as water, energy and chemical consumption. However, combining desizing and wet abrasion processes can present specific technical issues, such as severe streaking and back staining from the large amounts of dye present in the desizing bath.

These issues can be overcome by using two specific types of cellulase enzyme in combination—one designed for abrasion assistance, and the other designed for streak reduction/prevention. Enzymes are added to the processing bath in a specific sequence or are selected to have an appropriate "dormant" period (i.e., the enzyme is not activated until the proper time during the washing cycle). This strategy is sometimes called a "combi-process."

WASTE MINIMIZATION/SOURCE REDUCTION

Strong consideration should be given to whether a garment washing process is truly warranted. On certain products (e.g., denim), some form of garment washing is necessary—to remove the sizing agents present on the warp yarns, for example. On other products, such as knit tops, garment washing may not always be required. For example, where garment washing is performed to reduce the hairiness/pilling propensity of knit garments, fibre selection (e.g., less short fibre or lower-tenacity fibre) and/or modifications to the yarn (less twist) can sometimes eliminate that need. Where garment washing is performed to reduce the torque/skew or shrinkage in garments, some procedures in the manufacture of the fabric, such as Sanforizing, may suffice. And where garment washing is used to achieve a faded aesthetic, starting with a fabric shade closer to the desired garment shade after wash can significantly reduce the degree of decolourization (and associated energy, dye-stuff and waste) necessary.

ECO-AGING

Eco-aging is an alternative to sandblasting created by Fimatex in Italy. It's a fading process that uses a vegetable mix composed of waste from food and is said to be biodegradable.[3]

OPTIMIZE SUSTAINABILITY BENEFITS

DESIGN OPPORTUNITY	CONSIDERATIONS
Look for opportunities to avoid garment washing.	Fabric suppliers will need prompting to show physically engineered fabrics, if these wash-saving processes have not been requested before.
Select fabrics that are closer in shade to the desired garment shade after wash.	Speaking with a technical person, rather than a sales person, may be necessary.
Encourage water conservation with existing suppliers and/or seek new suppliers that use water conservation techniques. Create awareness that water and energy conservation is important and possible, without sacrificing hand-feel or aesthetic.	Water use by garment laundries varies widely.
Promote proper wastewater treatment.	Water treatment by garment laundries varies widely.
Leverage the aesthetic differences that low impact garment washes offer. Turn the differences into positive stories.	

MARKETING OPPORTUNITIES

1. Water conservation (gallons of water saved per item) when ozone bleaching is used.
2. **non-chlorine bleached**: If alternative bleach is used.
3. Laser treatments replacing conventional wet abrasion finishes could appeal to an increasingly tech-savvy consumer base.
4. Providing educational information on the social responsibility or brand website could detail information about lower impact processes for washing, finishing and bleaching.

1. blog.stylesight.com/denim/sandblasting-ban-update
2. www.mercurynews.com/business/ci_24407198/retailer-sandblasting-bans-have-changed-little-garment-industry
3. www.fimatexgroup.it/

GLOSSARY

antichlor
Any of various substances, especially sodium thiosulfate, used for removing excess chlorine from paper pulp, textile, fibre, etc., after bleaching.

bioaccumulate
The accumulation of substances, such as pesticides, or other organic chemicals in an organism.[1]

biodegradable
A fibre or garment that can be broken down into simpler substances by microorganisms, light, air or water in a process that must be non-toxic.[2]

biodiversity
An ecosystem containing a variety of species.

biological oxygen demand (BOD)
Biochemical oxygen demand is a measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter. Natural sources of organic matter include plant decay and leaf fall. However, plant growth and decay may be unnaturally accelerated when nutrients and sunlight are overly abundant due to human influence. Urban and industrial runoff carries nutrients from lawn fertilizers and leaves, grass clippings and paper from residential areas, which increase oxygen demand.[3]

carcinogens
A carcinogen is an agent that can cause cancer. Carcinogens can be chemicals, viruses, hormone, ionizing radiation, or solid materials.

chemical oxygen demand (COD)
The standard method for indirect measurement of the amount of pollution (that can be oxidized biologically) in a sample of water.

chemical recycling
Breaking the polymer into its molecular parts and reforming the molecule into a yarn of equal strength and quality as the original.

chromophoric
Any chemical group that produces colour in a compound, such as the azo group.

carbon neutral
A term used to describe when organizations, businesses and individuals take action to remove as much carbon dioxide from the atmosphere as each puts into it. This practice is often called carbon offset or offsetting.

chronic
Lasting for a long period of time.

closed loop process
Production system in which the waste or byproduct of one process or product is used to provide nutrients for nature or industry in making another product.[4]

compostable
A product that is compostable" is one that can be placed into a composition of decaying biodegradable materials, and eventually turns into a nutrient-rich material.

decompose
To become broken down into components; disintegrate.

deforestation
Deforestation is the removing or clearing of a forest to include the cutting of all trees, mostly for agricultural or urban use. The remaining land is not reforested but is usually converted to a non-forest classification.[5]

degradability
Degradable fibres are based on synthetic polymers from oil but do decompose, though this process takes several years.[6]

desertification
Desertification is the process which turns productive desert into non-productive desert as a result of poor landmanagement.[7]

dissolved oxygen (DO)
Oxygen is measured in its dissolved form as dissolved oxygen (DO). If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken or die.[8]

downcycling
Downcycling is the recycling of a material into a material of lesser quality. For example, the material recycling of plastics, which turns them into lower grade plastics.

durable water repellent (DWR)
A coating added to fabrics at the factory to make them water-resistant (or hydrophobic).

emissions
Emissions is the term used to describe the gases and particles which are put into the air or emitted by various sources.[9]

enzymes
Any of various proteins, such as pepsin, originating from living cells and capable of producing certain chemical changes in organic substances by catalytic action (as in chemistry).

Fairtrade
An global program that secures a minimum fibre price for the farmer aiming to cover the average costs of sustainable production.

fast-fashion
Fashion or products that are designed and produced in a short period of time and likely used and disposed of in a short period of time by the consumer.

Forest Stewardship Council (FSC)
FSC is an independent, non-profit organization that protects forests sets standards under which forests and companies are certified.[10]

Genetically modified Bt cotton
The most successful variety of genetically modified cotton which has been engineered so that the genetic code of the plant includes a bacterial toxin (*bacillus thuringiensis*) that is poisonous to pests. This means that the crop comes under attack less often which requires fewer pesticides sprays.[6]

Global Organic Textile Standard (GOTS)
Recognized as the world's leading processing standard for textiles made from organic fibres. It defines high-level environmental criteria along the entire organic textiles supply chain and requires compliance with social criteria as well.[11]

glutaraldehyde
A colourless, oily, liquid-chemical with a pungent odour.[12]

halogenated organic compounds (AOX)
AOX stands for "Adsorbable Organically Bound Halogens" expressed as chloride, and determined according to the relevant European Standard method. AOXs are substances that are adsorbed from water onto activated carbon. They may be volatile substances like trichloromethane (chloroform), chlorophenole and chlorobenzenes or complex organic molecules like dioxins and furans. Most AOXs are chlorine-containing molecules, but bromo- and iodo-AOXs may also occur.[13]

humectants
A substance that absorbs or helps another substance retain moisture, as in glycerol, for example.

Integrated Pest Management (IPM)
Integrated Pest Management (IPM) is an environmental approach that focuses on long-term prevention of pests by integrating biological control, habitat manipulation and modification of cultural practices. Pesticides are used only after monitoring and established guidelines indicate pests exceed acceptable levels.[14]

International Federation of Agriculture Movements (IFOAM)
IFOAM is the worldwide organization for the organic movement, uniting more than 750 member organizations in 116 countries. IFOAM maintains organic farming standards, and organic accreditation and certification service.[15]

irrigation
To supply (dry land) with water by means of ditches, pipes or streams.

lyocell
Lyocell is the generic name for a biodegradable fabric that's made out of treated wood pulp. TENCEL® is the brand name.

mechanical recycling [of polyester]
A recycling process in which used PET bottles and leftover materials from manufacturing processes are remelted and remolded to make yarns for recycled polyester. Mechanical recycling downcycles plastic into lower grade plastics, until they eventually end up in the landfill.[16]

mordant
A mordant is a substance used to set dyes on fabrics or tissue sections by forming a coordination complex with the dye which then attaches to the fabric or tissue.[17]

mutagens
A substance or preparation capable of inducing mutation.

non-renewable resource
A resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human timeframes.

OEKO-TEK certified[18]
OEKO-TEK is an independent, third party certifier that offers two certifications for textiles: OEKO-TEK 100 (for products) and OEKO-TEK 1000 (for production sites/factories). OEKO-TEK 100 label aims to ensure that products pose no risk to health. These products do not contain allergenic dye-stuffs and dye-stuffs that form carcinogenic aryl-amines, and several other banned chemicals. The certification process includes thorough testing for a long list of chemicals.

OE 100 Standard[19]
The OE 100 Standard is a standard for tracking and documenting the purchase, handling and use of 100% certified organic cotton fibre in yarns, fabrics and finished goods. The OE 100 Standard helps consumers and companies confirm the correct percentage of organic cotton in their product.

organic
Disallows the use of genetically modified (GM) seeds and restricts or disallows the use of many synthetic agricultural chemicals.

organic in-conversion cotton
Uses non-GM seed and is grown in the same manner as organic but is still transitioning through the 2-year phase to certification under the European organic standard. Once the land on which it is grown has completed the 2-year requirement, the fibre can be labeled as organic.

post-consumer waste
Includes used and discarded products (e.g., garments, carpet, automotive upholstery) that are collected, deconstructed if necessary, and either recycled and used as raw material in the textile facility or sold and used for some other purpose unrelated to textiles and apparel. Post-consumer recycled cotton tends to be downcycled.

post-industrial waste
Post-industrial waste (also known as pre-consumer waste) utilizes material created during product manufacturing. Examples of post-industrial waste include selvage from weaving, fabric remnants, cutting room waste, excess production, inventory and unsold items.

Programme for the Endorsement of Forest Certification (PEFC)
The Programme for the Endorsement of Forest Certification (PEFC) is an international non-profit, non-governmental organization dedicated to promoting Sustainable Forest Management (SFM) through independent third-party certification.[20]

retting
A process that separates bast fibre (e.g. jute, flax, hemp, bamboo) from the stems using microorganisms and moisture. This is carried out in the field (as with dew retting) or in tanks (water or chemical retting).

Roundup Ready®/Herbacide tolerant (Ht) cotton
Cotton seed, developed by Monsanto, that contains a gene not normally found in cotton plants. The gene allows the plants to withstand Roundup® herbicide. Cotton growers can spray their fields with Roundup herbicide to control weeds without damaging the cotton plants.[21, 22]

recyclable
To pass through a cycle again; repeat a process from the beginning.

renewable natural resource
Natural resources that can be replaced or replenished by natural processes or human action.

Sanforizing™
Sanforizing is a controlled compressive shrinkage process, which is applied on woven fabric to achieve shrinkage before making the garments. After sanforizing the residual shrinkage of woven fabric may be zero.[23]

scouring
Scouring removes top finishes, largely accomplished by rinsing with an appropriate detergent.

sericin
A viscous gelantinous protein that forms on the surface of raw silk fibres.

teratogens
A chemical capable of interfering with the development of a fetus, causing birth defects.

thermoplastics
Of or relating to a compound that can be repeatedly made soft and hard through heating and cooling. Polyethylene and polystyrene are thermoplastic resins.

United States Environmental Protection Agency (EPA)
An agency of the U.S. federal government which was created for the purpose of protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress.

United States Federal Trade Commission (FTC)
An independent agency of the United States government that promotes consumer protection.

upcycling
To process (used goods or waste material) so as to produce something that is higher quality than the original.

Volatile organic compounds (VOCs)
Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects.[24]

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21. www.cals.ncsu.edu/agcomm/magazine/spring02/whenroun.htm
22. www.monsanto.com/weedmanagement/Pages/roundup-ready-system.aspx
23. textilelearner.blogspot.com/2012/02/sanforizinganti-shrinkage-finishing.html
24. www.epa.gov/iaq/voc.html

APPENDIX

WASTE-TO-ENERGY & ENCOURAGING REUSE

Waste-to-energy is a recovery method that creates energy from the incineration of waste, providing Europe with a significant part of its energy needs. Through this method Sweden generates energy equivalent to 1.1 million cubic metres (m3) of oil per year, resulting in the highest amount of renewable energy produced in the European Union.[1]

THE REUSE OF MATERIALS SHOULD BE CONSIDERED A PRIORITY BEFORE RELYING ON WASTE-TO-ENERGY INCINERATION. THIS ALLOWS FOR THE MAXIMIZATION OF THE EMBODIED ENERGY AND RESOURCES USED TO CREATE THE PRODUCT, AND THE ABILITY TO CAPITALIZE REPEATEDLY OFF THE SAME MATERIALS.

OUTSIDE OF THE EUROPEAN UNION

Any garments or products sold outside of the European Union could increase the load on landfills or end up in oceans and large bodies of water, where they can harm aquatic species and potentially end up back in our food and water.

According to a study done by Mark Browne, an ecologist at University College Dublin, microscopic fragments of acrylic, polyethylene, polypropylene, polyamide and polyester have been discovered in increasing quantities across the northeast Atlantic, as well as on beaches in Britain, Singapore and India.[2]

1 www.avfallsverige.se/fileadmin/uploads/forbranning_eng.pdf
2 www.ecouterre.com/is-synthetic-clothing-causing-microplastic-pollution-in-oceans-worldwide/

BIODEGRADABILITY

Although natural fibre is biodegradable, the amount of time it could take for a natural fibre product to decompose naturally and in a short period of time is dependent upon a number of conditions—including how much air, temperature and sunlight the fibre is exposed to. If the waste is buried in a landfill, it can take even longer for it to break down.

According to the European Commission, biodegradable waste does not include natural textiles.[1] The United States Federal Trade Commission (FTC) defines biodegradable in their Green Guide as a product or package that "completely breaks down and returns to nature, decomposing into elements found in nature within a reasonably short period of time after customary disposal."[2]

Natural fibre garments or products that are:

- …dyed with synthetic dyes
- …blended with synthetic fibres
- …sewn with synthetic thread or have synthetic trims
- …blended with natural fibres treated with chemical processes

… will take even longer to decompose, and will leave residues behind in the soil, which can be toxic.

1 ec.europa.eu/environment/waste/compost/
2 www.ftc.gov/news-events/media-resources/truth-advertising/green-guides

CONSUMER CARE AND WASHING

The consumer use phase of a garment or product can significantly contribute to its overall environmental influence. While consumer care and washing may seem out of the company's control, using effective product design and marketing to educate consumers could play a significant role in affecting the influence that a garment or product could have on the environment.

ENVIRONMENTAL IMPACTS

Laundry detergent

Certain at-home laundry detergents include ingredients that have been reported to have detrimental effects on humans and the environment.

- Sodium lauryl sulfate (SLS)/sodium laureth sulfate (SLES): Can cause irritation of the skin and eyes.[1]

- 1,4-dioxane: Possible carcinogen, bioaccumulative in the environment, groundwater contaminate, non-biodegradable.[2]

- NPE (nonylphenol ethoxylate): Persistent in the aquatic environment, moderately bioaccumulative and extremely toxic to aquatic organisms. Has been banned in Europe.[3, 4]

- Phosphates: Difficult to remove from wastewater and often ends up in rivers and lakes, where they cause algae blooms that negatively effect ecosystems and marine life. Has been banned in Europe for use in consumer detergents.[5]

Other ingredients including linear alkyl sodium sulfonates (LAS), petroleum distillates (a.k.a. naphthas), phenols, optical brighteners, sodium hypochlorite (bleach), EDTA (ethylene-diamino-tetra-acetate) and artificial fragrances, have also been linked to various toxic effects on fish and animals, as well as allergic reactions in humans.[6]

Dry-cleaning

Perchloroethylene (perc), the main chemical used in dry-cleaning, has been reported to have detrimental effects on humans and the environment and contributes to ozone depletion.

Ironing

Some fabrics, such as hemp and silk, wrinkle easily, and require heavy pressing to render it smooth after washing. This can use significant amounts of energy over the long-term.

CONSUMER CARE AND WASHING cont'd

SUGGESTIONS FOR CONSUMERS & INNOVATION IDEAS

- Encourage the use of "phosphate free," "no bleach," "SLE free" and "NPE free" detergents.
- Encourage the use of biodegradable detergents since these tend to not contain harmful ingredients.
- Encourage the use of plant- and animal-based ingredients, instead of petroleum-based.
- Encourage the use of concentrated detergents. These have reduced packaging.
- Encourage washing and rinsing in cold water.
- Encourage spot cleaning.
- Suggest alternatives to dry-cleaning with perc, including Solvon K4 and hydrocarbon solvents.
- Use fibres creatively and effectively to create garments or products that allow for less washing.
- Create a product where staining is intended as a design element, influencing the consumer to wash less.
- Create a garment that allows the consumer to detach and wash pieces of the garment that readily get soiled, saving on water.
- Design garments that utilize the natural wrinkling of the fabric as a design feature to influence reduced use of energy by customers to iron the garment.

USE THE HANGTAG AND LABELING/POS TO COMMUNICATE THESE SUGGESTIONS AND INFLUENCE THE CONSUMER TO TAKE AN ACTIVE ROLE IN REDUCING ENVIRONMENTAL IMPACTS.

1 www.ewg.org/skindeep/ingredient/706089/SODIUM_LAURETH_SULFATE/
2 www.ewg.org/skindeep/ingredient/726331/1%2C4-DIOXANE/
3 www.epa.gov/oppt/existingchemicals/pubs/actionplans/np-npe.html
4 www.tfl.com/web/files/Statement_NPE-surfactants.pdf
5 europa.eu/rapid/press-release_IP-11-1542_en.htm

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