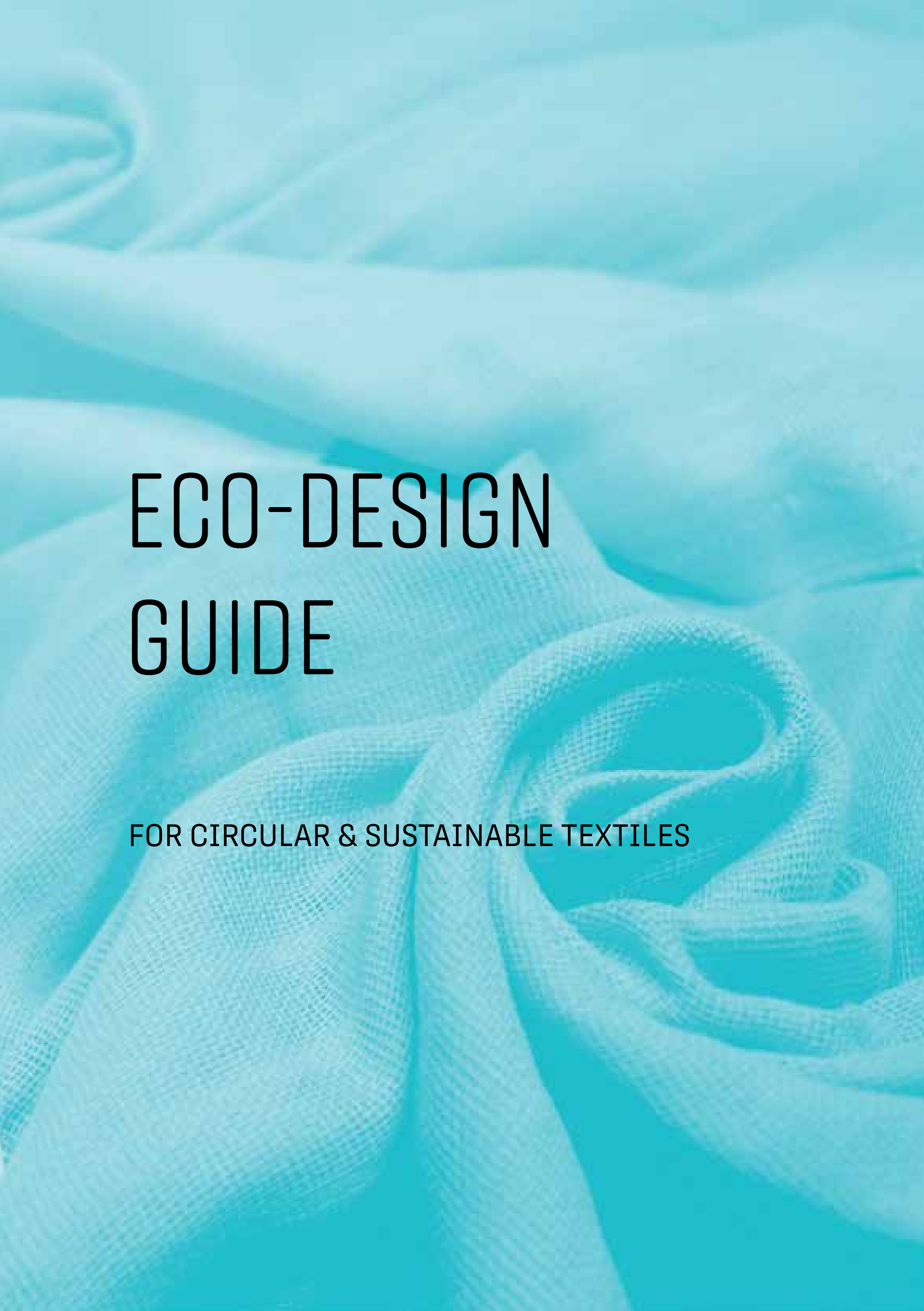

ECO-DESIGN GUIDE

FOR CIRCULAR & SUSTAINABLE TEXTILES

COLOPHON

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THE INFORMATION AND GUIDANCE IN THIS ECO-DESIGN GUIDE ARE INTENDED TO CONTRIBUTE TO A BETTER UNDERSTANDING OF THE ECOLOGICAL IMPACT OF TEXTILES. THIS IS INTENDED PURELY AS A GUIDANCE TOOL FOR TEXTILE DESIGNERS AND MANUFACTURERS. DESIRING TO CREATE SUSTAINABLE AND CIRCULAR TEXTILE PRODUCTS.

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INTRODUCTION

THE IMPORTANCE OF ECO-DESIGN

By definition, eco-design is the integration of environmental aspects into the design and development of products, with the aim of reducing negative environmental impacts throughout the life cycle of a product, while maintaining its quality of use.

This is a potentially complex and challenging agenda to address.

Thus, in addition to the materials necessary for the manufacture of products, eco-design can also cover many aspects linked to the mode of production and distribution.

Use, which covers for example maintenance methods and repair possibilities, will also be studied. In addition, measures related to quality improvement or reuse possibilities will aim to extend the life of products and postpone the end of their life.

Eco-design is therefore a necessary step in most of the transition processes from the linear economy to the circular economy. A journey that comes with its own set of questions and that requires making choices and also compromises.

This guide provides an introduction to many simple technical aspects of eco-design in the textile sector.

Material selection, basic vocabulary, the basics of textile technology, and the main labels that cover the eco-performance of a product or its manufacturing process are, for example, covered in a concrete way.

The main quality characteristics of a textile material and how to test them are also covered as they determine to a large extent the life of the product.

We hope that this 'Eco-design guide for circular and sustainable textiles' will help you in your choices.

EUROPEAN TEXTILES IN THE CIRCULAR ECONOMY

The necessary transition from the linear economy to the circular economy also represents a major challenge for the textile sector. Indeed, behind the apparent simplicity of the concept of circularity, which is partly based on common sense, lies a real complexity when one moves from theory to practice.

Many initiatives launched by young entrepreneurs start from a blank page and directly integrate a maximum of concepts related to the circular economy.

On the other hand, on an industrial scale, and for companies that have long been active in technical textiles, the situation is quite different. The global competitive context, the large quantities and the technical specificities represent major challenges at both strategic and technological levels.

EU-STRATEGY

The transition is also underway at the European level. The European Union's strategy for sustainable and circular textiles is ambitious and will oblige the major players in the sector to mobilise. It aims to create a greener, more competitive and more resilient sector.

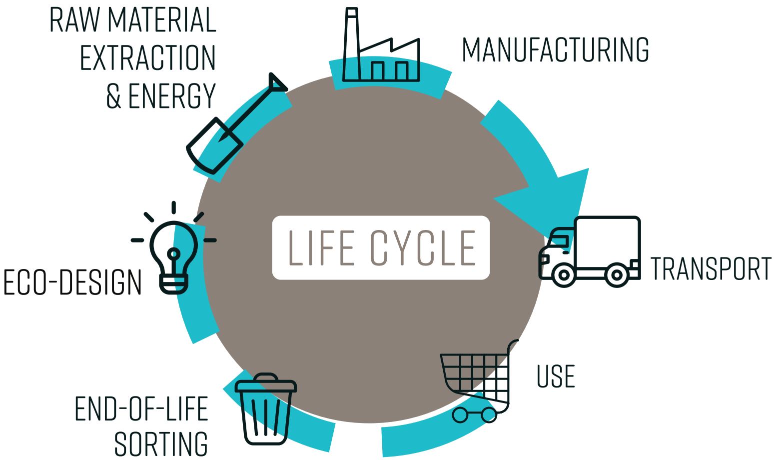
The Commission's 2030 vision for textiles is as follows

- Textile products placed on the EU market are sustainable, repairable and recyclable
- Textile articles are mainly made from recycled fibres, free of hazardous substances and produced in a socially and environmentally responsible way
- Fast fashion is no longer fashionable and consumers benefit for longer from high quality textiles at affordable prices
- Cost-effective reuse and repair services are widely available
- The textile sector is competitive, resilient and innovative, with producers taking responsibility for their products along the value chain, with sufficient recycling capacity and minimal incineration and landfilling

The Commission's strategy presents a set of forward-looking actions:

- Setting design requirements for textiles to make them last longer, be easier to repair and recycle
- Clearer information on textiles and a digital product passport
- Empowering consumers and fighting greenwashing by ensuring that companies' environmental claims are accurate
- Stop overproduction and overconsumption, and discourage the destruction of unsold or returned textiles
- Harmonise EU rules on extended producer responsibility (EPR) for textiles and economic incentives to make products more sustainable
- Tackling unintended release of microplastics from synthetic textiles
- Addressing the challenges posed by the export of textile waste
- Adopting a European toolkit against counterfeiting

TERMS & DEFINITIONS



ECO-DESIGN

Eco-design is defined as a systematic approach, which considers environmental aspects in design and development with the aim to reduce adverse environmental impacts throughout the life cycle of a product (ISO 14006:2020).

Moreover, this should be done while maintaining the quality of use of the products, which represents a potentially complex and delicate programme to tackle.

Thus, in addition to the materials needed to manufacture products, eco-design can also cover many aspects related to the mode of production and distribution. Use, which covers for example maintenance methods and repair possibilities, will also be studied. In addition, measures related to quality improvement or repair and reuse possibilities will aim to extend the life of products, and thus postpone the end of life.

Eco-design is a necessary step in most of the transition processes from the linear economy to the circular economy.

ECO-LABEL

A label is a compact and visual logo (words and symbols) applied to products and services. It certifies that a product or service has been designed in accordance with certain quality criteria or standards. It is also a value symbol that can guide consumer preferences.

A LABEL CAN SERVE DIFFERENT PURPOSES:

- Helping consumers to decide on a purchase
- To distinguish from the competition
- Influencing the market in a certain direction
- Establish a benchmark in public procurement (e.g. European Ecolabel, social labels, fair trade labels)

There are different types of labels but some general rules can be taken into account (FPS Economy - Belgium):

- a label is only valuable if the criteria are stricter than national legislation or international standards;
- the criteria are developed in consultation with all stakeholders (producers or sector organisations, consumer organisations, trade unions, NGOs);
- the organisation monitoring the criteria is recognised and independent (accredited);
- the organisation managing the label is transparent about the criteria used and the verification methods

There are all kinds of eco-labels, just for textiles and clothing. They each have different objectives and highlight a range of benefits and properties.

Some are issued by an independent body, some by the producer himself, and some are imposed by legislation.

BIO-ORGANIC

Organic textiles are produced without the use of synthetic pesticides, fertilisers or GMOs (genetically modified organisms), following the principles of organic agriculture aimed at preserving the health of ecosystems, soils and people. Many different fibres can be organic, such as cotton, hemp, linen, jute.

Animal fibres, such as wool, can also be 'organic', provided that the animals are raised in certified organic conditions.

To qualify as organic, fibres must be certified. For example, the most widely used organic fibre is undoubtedly cotton. While conventionally grown cotton is criticised for its many negative environmental impacts (amount of water used for irrigation, chemical substances harmful to humans and soil), organic cotton is praised for its qualities.

There are many definitions of circular economy, including:

- The circular economy is an economic system of exchange and production which, at all stages of the life cycle of products (goods and services), aims to increase the efficiency of resource use and decrease the impact on the environment while allowing for the well-being of individuals. (ADEME, France)
- Circular economy: Economic system that uses a systemic approach to maintain a circular flow of resources by regenerating, retaining or adding to their value, while contributing to sustainable development. (ISO 59004:2023, draft)

The levers for action are numerous and cover the entire life cycle of products and services:

- Sustainable sourcing of resources
- Eco-design
- Industrial and territorial ecology
- Functionality economy
- Responsible consumption (purchasing, collaborative consumption)
- Extending the duration of use and life (reuse, repair, re-utilisation)
- Recycling

They involve all actors in the value chains: producers, suppliers, consumers.

In the context of the circular economy, reference is often made to the Lansink scale (see below). It proposes a classification of strategies that concern the use of resources or ways of dealing with EOL products.

RETHINK	1	refuse
	2	rethink
	3	reduce
EXTEND	4	reuse
	5	repare
	6	refurbish
	7	remanufacture
OPTIMISE	8	recycle
	9	energy recovery
DESTROY	9b	incinarate
	10	landfill

TEXTILE FIBRES

AND THEIR ENVIRONMENTAL IMPACT

NATURAL TEXTILE FIBRES

ANIMAL FIBRES

silk
wool
hair

VEGETABLE FIBRES

seed

cotton
kapok

bast

flax
hemp
jute
kenaf
ramie

leaf

manila
henequen
sisal

fruit

coir

MINERAL FIBRES

asbestos
glass
basalt

MAN-MADE TEXTILE FIBRES

INORGANIC FIBRES

carbon
ceramic
glass
metal

form natural sources

acetate
triacetate
alginate
cupro
rubber
lyocell
modal
viscose

from fossil sources

acrylic
modacrylic
chlorofibre
elastane
elastodiene
fluofibre
polyamide
polyester
polyethylene
polypropylene

from biological sources

PLA
PHA
PHB
PEF
PBS

TECHNICAL FIBRES

Kevlar®
Nomex®
PBI®
Dyneema®
PEEK®

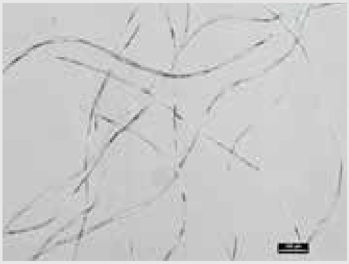
A wide variety of fibres from different sources and with different properties are available to the textile industry. These fibres are used to make the clothes we wear or the upholstery we sit on. Some are well known, such as cotton, flax, polyester, and nylon. Others, such as polybenzimidazole (PBI), carbon or basalt fibres, are only used in technical applications and are less common in everyday textiles.

Textile fibres come from many sources. Some are derived from plants, others from animals or even minerals. There are also fibres made from petroleum-based chemicals. Some are very popular, such as polyester and nylon, and are used in a wide range of applications.

In recent years, driven by sustainability concerns, new types of fibres have been produced from renewable resources and more efforts are being made to recycle fibres.

This guide does not claim to cover all types of textile fibres. However, it aims to give the reader a basic understanding of the characteristics of some of the most important fibres. It aims to enable product designers to make informed choices when selecting textiles.

COTTON



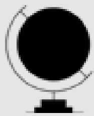
Cotton is the best known textile fibre. It is used in a variety of non-technical applications. The fibre is grown in several countries, with India, China, the USA and Brazil producing around 70% of the world's consumption.

Cotton is a renewable fibre, but unfortunately its production requires large amounts of water and pesticides.

The entire harvest, from sowing to harvest, takes 6 to 7 months. Cotton is sown after the frost period. The plant grows for the first 2 months and then flowers. After the corolla has fallen, a seed box develops. The cotton fibres grow on the seeds inside the boll. After about 25 days the fibres are fully grown and the boll is broken open. The cotton fibres appear. One week after opening, the cotton is picked. Picking is done by machine or by hand. The fibres and seeds are picked at the same time. This is called seed cotton. The seed cotton is collected after the harvest and transported to the ginnery. Special machines separate the fibres from the seeds. After ginning, 100 kg of seed cotton is left with 35 kg of fibre, 62 kg of seeds and 3 kg of waste.

Cotton fibres are short and fine. The length depends on the variety and ranges from 10 to 50 mm with an average of 26 mm. They are very fine fibres compared to many other textile fibres. Cotton fibres have a bone-shaped cross-section and in the longitudinal direction they have fibre twists which are very characteristic of the fibre (only visible under a microscope). Cotton fibres are unicellular fibres, consisting almost entirely of cellulose.

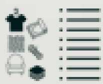
Organic cotton is also grown today. The cultivation of organic cotton is subject to the strict rules of organic farming, which limit or prohibit the use of pesticides and genetically modified plants. Organic cotton is said to use between 75% and 91% less water than regular cotton.



CHINA	33 %
INDIA	21 %
USA	12 %
PAKISTAN	8 %

BRAZIL, UZBEKISTAN, AFRICA, TURKEY, EU

SOFT, RESISTANT,
HYDROPHILIC, BREATHABLE,
HYPOALLERGENIC
SHORT & FINE FIBRES
POOR INSULATING CAPACITY
TENDENCY TO CREASE AND SHRINK



CLOTHING
HOUSEHOLD LINEN
UPHOLSTERY
CURTAINS
CARPETS
TECHNICAL TEXTILES

Renewable
Recyclable
Helps soil regeneration
Biodegradable/compostable (under strict conditions)
No microplastics

Organic cotton: much lower environmental impact

Locally grown cotton available: limited cotton production in Spain and Greece

The quality of cotton yarns depends on fibre length.
The quality of cotton fabrics depends on fibre and yarn qualities.
A similar fabric in weight and look can show very different performance levels.

Mechanical recycling: cotton to cotton

- potential high waste level due to short fibres and dust, indicating quality loss during polymerisation
- must be mixed with virgin fibres for strength

Chemical recycling: cotton to viscose

Long distance transportation
Very high water consumption if irrigation in place
conventionally cultivated cotton:

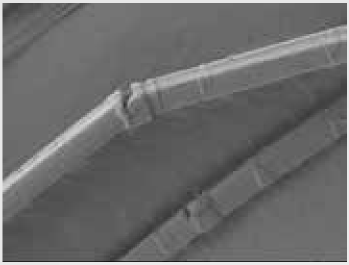
- High use of pesticides
- Soil, water and air pollution

GOTS - Global Organic Textile Standard
BCI (Better Cotton Initiative)

WIDE VARIETY OF USES
BREATHABLE
NATURAL
POSITIVE PUBLIC PERCEPTION OF ORGANIC COTTON
ANALLERGIC

AREAS WITH FORCED LABOUR
TENDS TO SHRINK IN WASHING
DECLINING REPUTATION OF CONVENTIONAL COTTON (WATER, PESTICIDES, ETC.)
POOR INSULATION

FLAX



Flax is a bast fibre obtained from the flax plant (Linum usitatissimum).

The flax plant is made up of several layers, and the flax fibres are bound in bundles between the edge fabric and the wooden tube of the plant. They give the plant its strength. The plant glue that holds the fibres in the plant is made up of pectins, lignins and hemicelluloses. In order to remove the fibres from the plant, this glue is removed and a few mechanical operations are carried out to release the fibres.

Flax is a perennial crop and must be sown every year. This takes place between 15 March and 15 April. Flax can only be sown in the same field every 6 years. If flax were grown on the same field for several years, both yield and quality would be greatly reduced. Flax is harvested 100 to 120 days after sowing (July). This is done before the seed is ripe. The next step is to remove the layer of glue that holds the fibres in the plant. This is done in a biological way and is called retting. In dew retting, the most commonly used process, the flax is left in the field after harvesting. Here the pectinic substances are dissolved by fungi. This process takes about 5 to 7 weeks. Mechanical operations are then carried out to separate the fibre from the woody part of the plant. The first operation is to break the flax stalks. This operation is followed by the "zwingeling" process, in which the broken stalks are separated from the fibre. This process produces two types of flax fibre: long flax and short flax. Both are used as textile fibres. The long flax fibre allows finer and stronger yarns to be spun.

There are several countries that grow flax, but the main producers of textile flax are France, Belgium and the Netherlands. Because of their location, climate and expertise, these countries produce the best flax in the world. Together, these countries produce about 80% of the world's flax fibre. The cultivation area stretches along the coast from Caen to Amsterdam.

Other flax producing countries are China, Canada (mainly oil flax), Belarus and the Russian Federation.

FRANCE
BELGIUM
NETHERLANDS
CHINA
UKRAINE
RUSSIA

HIGHLY RESISTANT
HYDROPHILIC
BREATHABLE
COMFORTABLE
SOFT
FLEXIBLE

HOUSEHOLD LINEN
CLOTHING
DECORATION
TWINE AND ROPE (COARSER FIBRES)
COMPOSITES

Renewable
Low demand on pesticides and fertilizers
No irrigation required (EU)
Promotes soil regeneration
Biodegradable/compostable (under strict conditions)

EU flax and spun yarns

Organic flax available (in low quantities)

Can be mixed with other fibres (e. g. cotton) to reduce wrinkling and price.

Mechanical recycling
Chemical recycling (cellulose to viscose)

Impact retting if it doesn't take place on the field
Transportation when imported from China

MASTERS OF LINEN®

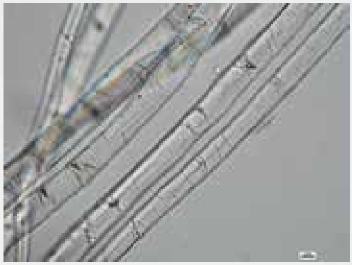
EUROPEAN FLAX® (traceability)

GOTS - Global Organic Textile Standard

POSITIVE IMAGE
OVERALL HIGH-QUALITY PRODUCTS
LOCAL SUPPLY CHAIN IS POSSIBLE
ANALLERGIC

EXPENSIVE
CREASES EASILY

HEMP



Hemp (industrial hemp) is a plant grown for its bast fibre. The fibre from this fast-growing plant is used in many different applications including rope, carpets, insulation and paper. Hemp also contains a psychoactive component called tetrahydrocannabinol (THC), which makes its cultivation subject to strict regulations that can vary from country to country.

Today, hemp is mainly used in industrial applications, although there is growing interest in the fibre for use in clothing or home textiles (sometimes blended with other fibres). Flax and hemp belong to the same fibre family. They are both cellulosic and bast fibres and are processed in the same way.

However, hemp fibres are considerably longer than flax fibres and slightly coarser. It is very difficult to distinguish flax from hemp. Even microscopic analysis is not always conclusive, which can lead to fraud.

Hemp cultivation in Europe is limited compared to flax but is growing rapidly. Several initiatives are underway and cultivation has increased significantly from 19,970 ha in 2015 to 34,960 ha in 2019.The technology to extract the fibres is also being developed and is necessary for a successful hemp business. France is the largest producer, accounting for more than 70% of EU production, followed by the Netherlands (10%) and Austria (4%).

From a sustainability point of view, hemp is comparable to flax. The plant does not require pesticides to be protected against insects.

CHINA (50%)
EU
RUSSIA
ALGERIA
USA

HIGHLY RESISTANT
HYDROPHILIC
BREATHABLE
COMFORTABLE & SOFT
FLEXIBLE
OTHER PARTS OF THE PLANT CAN BE USED IN OTHER PRODUCTS (INSULATING, ETC.).

HOUSEHOLD LINEN
CLOTHING
TWINE AND ROPE (COARSER FIBRES)
CANVAS
COMPOSITES

Renewable
Low demand on pesticides and fertilizers
No irrigation required (EU)
Promotes soil regeneration
High yield
Biodegradable/compostable (under strict conditions)

EU-grown hemp and EU-made spun yarns

Organic hemp available (in low quantities)

Can be mixed with other fibres (e. g. cotton) to reduce wrinkling and price

Mechanical recycling
Chemical recycling (cellulose to viscose)

Impact retting if it doesn't take place on the field

GOTS - Global Organic Textile Standard

POSITIVE IMAGE
OVERALL HIGH-QUALITY PRODUCTS
LOCAL SUPPLY CHAIN IS POSSIBLE
ANALLERGIC

EXPENSIVE
CREASES EASILY

WOOL

Wool is a natural protein fibre that has been obtained from sheep - one of the oldest domesticated animals - for around 10,000 years. Sheep are usually sheared in spring or early summer.

With an annual production of approximately two million tonnes of raw wool fibre, sheep's wool is the most widely used animal fibre.

Except in rare cases, wool production is a by-product of sheep farming for food. The exceptions are fine wools, such as merino wool, from sheep bred specifically for textile production. The fibre is of high quality and is used in clothing. Each individual Merino sheep can produce up to 5 kg of fine, high quality wool per shearing.

The wool is naturally crimped and wavy, with an airy and slightly greasy feel to the touch before it is treated. Most wools are yellowish-white or ivory, but some can be black, brown, grey or random blends.

The environmental impact of wool production is not high: the main issues are soil pollution from animal husbandry and waste from the early stages of processing: the fleece is washed and cleaned to remove pests and grease before spinning, and white wool often requires bleaching. These stages can result in losses of up to 45%.

In some cases, wastewater is reused for alternative products, such as lanolin (a wax used in cosmetics) or as an additive to clay used in brick making.

The energy consumption for washing wool is quite high, however, along the entire process of wool fibre production, the value of energy used is lower than other fibres, both natural and man-made, up to 5 times.

Wool fibres range in thickness from 10-50 microns and in length from 40 to 115 mm.

Other fine wools include Mohair (form the hair of the angora goat, different to angora rabbit which is also known as angora rabbit), Alpaca (a South American camelid), Guanaco llama and vicuna (camelids from South America): are characterized by long, fine fibres with greater tenacity, less elongation and lower tendency to felting.

Recycled wool has a long tradition. With an estimated world production of around 70 thousand tonnes.

AUSTRALIA, RUSSIA, NEW ZEALAND, AND KAZAKHSTAN LEAD IN FINE-WOOL PRODUCTION

INDIA LEADS IN THE PRODUCTION OF THE COARSER WOOLS KNOWN AS CARPET WOOLS

RESISTANT TO BREAKAGE (WHEN DRY)
HYDROPHILIC
BREATHABLE
COMFORTABLE & SOFT
INSULATING
EXCELLENT AFFINITY FOR DYESTUFFS

CLOTHING

CARPETS

UPHOLSTERY

HOUSEHOLD LINEN

Renewable
Easy to recycle
Degradable in nature

Depending on the animal, the fibres range from very fine to very coarse

Can be mixed with other types of fibres

Mechanical recycling

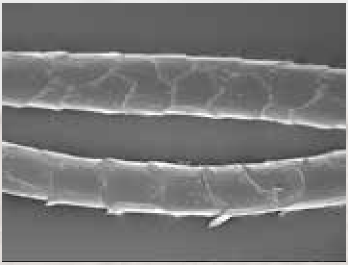
Soil pollution due to animal breeding
Waste generated by fleece washing, bleaching

Woolmark®

NATURAL PRODUCT
OVERALL HIGH-QUALITY PRODUCTS
LOCAL SUPPLY CHAIN IS POSSIBLE
ANALLERGIC

EXPENSIVE

CASHMERE



TIBET, CHINA, MONGOLIA, INDIA, IRAN AND AFGHANISTAN

Cashmere wool is obtained from the cashmere goat that lives in Tibet, China, Mongolia, India, Iran and Afghanistan.

Cashmere is collected only from the undercoat of the cashmere goat.

It is highly valued because it is fine (between 11 and 18 microns) and long (about 90 mm on average). The cashmere fibre is much appreciated for its softness and lustre.

On the other hand it has lower strength than sheep's wool, is more hygroscopic and sensitive to chemicals, especially alkalis.

The low-gloss fibre is generally grey, brown and white. Because of its rare production, the fibre is considered very luxurious, and is sometimes mixed with very soft wool.

SOFT
THERMAL COMFORT
LUSTRE
LUXURIOUS

HIGH-END CLOTHING

Renewable
Easy to recycle
Degradable in nature

Very fine and long fibre
Sensitive to chemicals
For luxury clothing products

Can be mixed with other types of soft wool

Mechanical recycling

Soil pollution due to animal breeding
Waste generated by fleece washing, bleaching

Woolmark®

NATURAL PRODUCT
OVERALL HIGH-QUALITY PRODUCTS
ANALLERGIC

EXPENSIVE

SILK

Silk is one of the oldest known luxury natural fibres.

Silk is the only natural filament fibre and is soft, lustrous, shiny and smooth to the touch.

Silk is produced by the silkworm, which is particularly sensitive to the environment in which it is reared. For this reason, silkworms are reared under controlled conditions: the air must be clean and the temperature and humidity must be precisely regulated. The food is mulberry leaves, grown with little fertiliser and with few pesticides, which would be counterproductive given the worm's extreme sensitivity.

Once the cocoon is formed, the pupa is killed by steam, which is also used to unravel the thread. It is then washed with hot water and neutral detergents.

Each cocoon can produce almost two kilometres of filament.

Wastewater therefore has a low environmental impact, much less than in the case of cotton and man-made fibres.

In recent years, concern for animals and the environment has led to the emergence of a more sustainable type of silk: "wild silk", in which silkworms are reared in open forests without the use of dangerous chemicals, and the moth is left free to hatch and break the cocoon.

This produces short filaments, which are then scoured with neutral detergents as with traditional silk. The fibres are then spun using discontinuous spinning techniques, making them more similar to other natural fibres.

CHINA
INDIA
UZBEKISTAN

SOFT
LUSTRE
SMOOTH
LUXURIOUS

HIGH-END CLOTHING

BEDDING

UPHOLSTERY

CURTAINS

PERSIAN CARPETS

Renewable
Low impact during cultivation
Degradable in nature

Very fine and long fibre
Sensitive to chemicals
For luxury products

Can be blended with other fibres to reduce price
Delicate, requires careful handling

Mechanical Recycling
Chemical recycling under development (also for a wide range of applications)

Largest impacts due to fabric dyeing and finishing
Only a few specific recycling technologies available

OCS - Organic Content Standard
GOTS - organic

NATURAL
BREATHABLE
PREMIUM PUBLIC PERCEPTION

DELICATE TO HANDLE AND WASH
EXPENSIVE
SCARCE SUPPLY

VISCOSE

Viscose is the most important Man-Made Cellulosic Fibre, with a market share of around 80% and a production volume of around 5.8 million tonnes in 2021.

Hardwood forests are the main source of cellulose used in viscose production. This cellulose material is then dissolved in a chemical solution to produce a pulpy viscous substance. Using a wet spinning process, the pulpy viscous substance is extruded through a spinneret.

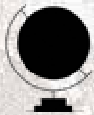
Viscose is associated with an intensive chemically processes compared to other cellulosic fibres such as lyocell. The production process releases many toxic chemicals into the air and waterways surrounding production plants. One of the chemicals used in this process is carbon disulphide, a hazardous air pollutant, traditionally known to cause cardiovascular, psychiatric, neuropsychological, endocrinal, and reproductive disorders. Moreover, the sourcing of wood to produce viscose includes deforestation and forest exploitation.

Standards for feedstock as Canopy and FSC/PEFC (Forest Stewardship Council/Programme for the Endorsement of Forest Certification) try to ensure that vital forest ecosystems are being used to manufacture the pulp to produce the fibres. In 2021, 60% of all global production of MMCFs was certified FSC/PEFC. Other types of raw material are emerging to produce more sustainable MMCFs fibres, such as agriculture and textile wastes.

At present, recycled raw materials can also be used, but they account for less than 1% of the market.

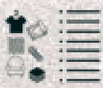
The typical cross-section for a viscose fibre is like a distorted circle with a serrated contour and the fibre surface is smooth but striated longitudinally.

The lustre varies from bright to dull. Viscose fibres possess excellent silk-like aesthetic properties, good feel and drape. Breathability, softness, comfort, and ease in dyeing are the other favourable properties of viscose fibres. It has good dry strength and abrasion resistance, but it has poor resiliency that leads to wrinkle formation. Its heat resistance is slightly less than that of cotton. To decrease costs and/or improve properties such as lustre, softness, absorbency, and comfort, viscose is often blended with many other fibres.



INDONESIA
CHINA
AUSTRIA
SINGAPORE
THAILAND

BREATHABLE
SOFT
COMFORT



CLOTHING
BEDDING
UPHOLSTERY
CURTAINS
SPORTSWEAR
OTHERS

Natural source (wood)

Biodegradable

Easy to recycle

Usually blended with other fibres

Looking for a viscose responsible production – Canopy, for example, focuses on ensuring that viscose pulp is not sourced from ancient or endangered forests.

Important to control the entire viscose process - from wood to fibre.

Commonly known as rayon

Vulnerable to greenwashing – for ex. bamboo viscose

Recyclable

The raw material wood used to produce the fibre can already be partly replaced by recycled content.

Chemically intensive processes

Deforestation

Wastes from production process

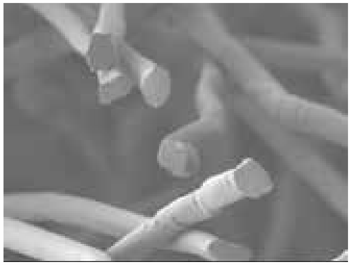
FSC® (Forest Stewardship Council)

PEFC™ (Programme for the Endorsement of Forest Certification)

WIDELY AVAILABLE

CHEMICALLY INTENSIVE PRODUCTION PROCESS

LYOCELL



Lyocell was first commercially produced in the early 1990's under the brand name "Tencel™". Later, Lenzing acquired and further developed the patented process. Since then, other large MMCF producers have entered the space. In 2021, lyocell was the third most used MMCF type (after viscose and acetate). It had a market share of around 4% of all MMCFs, with a production volume of around 0.3 million tonnes. Lyocell is growing in the market due, firstly, to the manufacturing process that is less chemically intensive than viscose and does not use toxic compounds as reagents, leading to a 99.7% solvent recovery rate; and it is a fibre with a greater strength compared to viscose and cotton.

Lyocell is produced in a closed loop. The raw materials for the lyocell process are wood from eucalyptus, oak and birch. Like viscose, the wood is broken down into tiny pieces and then chemicals are added to dissolve it into a wood pulp. The result is cellulose that is heated and broken into small pieces one more time using a solvent called NMMO (N-Methylmorpholine N-oxide). After being filtered, the cellulose goes through a spinning process that turns it into bright, long, and thin fibres. These fibres are washed, dried, and lubricated, until they're ready to be spun into a yarn.

Lyocell fibre has a close to circular cross-section. Its longitudinal surface is very smooth and cylindrical without any striation.

It possesses good moisture absorbency. Lyocell fibre presents high strength in both wet and dry conditions, unlike viscose. It can be easily blended with other fibres.

The advantageous features of fabrics made from lyocell fibre are wrinkle resistance, good stability to washing, dyeability to vibrant colours with a variety of effects and textures, and good drapeability.

CHINA
INDONESIA
AUSTRIA
UK
USA

SOFT
COMFORT
WRINKLE RESISTANT

CLOTHING
HOME TEXTILES
SPORTSWEAR
MEDICAL AND HYGIENE
FILTRATION
OTHERS

Natural source (wood)
Eco-friendly production process
Biodegradable
Easy to recycle

Usually blended with other fibres

Extensive fibrillation tendency

Commonly known as Tencel™

If the manufacturer does not grow the trees in sustainably managed forests, then this is a problem for the environment.

Vulnerable to greenwashing

Recyclable
The raw material wood, which was previously required to produce the fibre, can already be partially replaced by residues.

Energy used to produce and dissolve pulp

FSC® (Forest Stewardship Council)
PEFC™ (Programme for the Endorsement of Forest Certification)

COMFORTABLE AND WRINKLE RESISTANT FIBRE

ENERGY CONSUMING PRODUCTION PROCESS

BAMBOO, BANANA, ORANGE PEELS, STRAW

The global fibre production per person increased by more than 70% in the last 50 years and about 56% of this production is fossil-based. The production of man-made fibres based on other biomass sources is growing and present new, more eco-friendly solutions.

Cellulose-based textile fibre innovations will be replacing the use of traditional materials such as cotton, viscose, or polyester in the future.

One example is bamboo. Bamboo can be regenerated by using viscose or lyocell spinning. Resulting yarns present softness and a higher/weak wet strength if they are obtained by lyocell/viscose spinning, respectively. Bamboo is naturally antifungal and antimicrobial, presenting quick moisture absorption.

Also, residual banana plant parts are good cellulosic fibre sources for many applications, including textiles, pulp and paper, bio-composites, construction, and food packaging.

Many developments have been done in Finland. Spinnova created a sustainable fibre based on straw. It is manufactured by mechanically refining pulp into micro-fibrillated cellulose. It is used in a closed loop manufacturing without any harmful chemicals or solvents and there are no waste streams. The material can be recycled again without deteriorating the quality of the fibre. The fibre is low-carbon and biodegradable. The hand feel is closest to cotton or linen, and it takes dye well. The insulation capability is on a par with wool. Other fibre based on straw is Bio2Textile created by Fortum.

Other projects use recycled cotton as base material. SaXcell is a regenerated virgin textile fibre made from chemical recycled domestic cotton waste. The dry mixture, obtained by mechanical recycling, exists of different colours and is chemically decoloured and made suitable for the wet spinning process. Wet spinning can be done according Viscose or Lyocell processes. SaXcell fibre is stronger than cotton and other regenerated fibres and presents good dyeability.

GLOBAL

SOFT
FLEXIBLE
GOOD AFFINITY TO DYEING
STRONG

CLOTHING
HOME TEXTILES
SPORTSWEAR
TECHNICAL TEXTILES
OTHERS

Renewable
Alternative to the use of trees for the production of viscose
Often waste-based (banana plant, orange peels)

Many ongoing developments

The name “Bamboo” is misleading: the bamboo fibres disappear during the chemical processing and the end product is viscose.

Mechanical recycling
Chemical recycling under development

Pesticides (low quantities)
Risk of deforestion in favour of bamboo plantations

None

ANALLERGIC

PLANTS ARE USED TO PROVIDE CELLULOSE, NOT FIBRES.

POLYESTER

Polyester fibre was invented in 1941 and is now widely used in many standard and technical textiles, either in pure form or blended with other fibres such as cotton. It is the most widely used textile fibre. More than 50% of global fibre production is based on polyester.

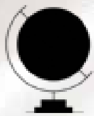
The polyester polymer is obtained from petrol resources and then transformed into a fibre by an extrusion process where the polymer is melted at minimum 230°C and pushed through small holes of a spinneret. The resulting filament is stretched to align the molecules such that the strength is increased. The filament can be used as such in a textile material or cut in short-length fibres to be mixed with other fibres such as cotton and spun into a yarn. Colouring of the fibre can be done during or after extrusion or spinning. During extrusion, colour is obtained by adding coloured pellets to the extrusion feeding. Also, after extrusion, the fibre can be dyed in a standard dyeing process.

Polyester fibres have excellent properties that can be further increased by means of a large range of additives to make them e.g. fire resistant, anti-microbial, etc., and hence suitable for a large range of applications. It has high strength and high abrasion resistance. It does not easily crease such that ironing is less needed. On the negative side it is less comfortable compared to natural fibres because it does not absorb much moisture. It can also cause pilling, which are small fibres balls that appear on clothing.

Polyester is highly resistant to washing and still has interesting end-of-life properties.

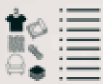
Mechanical or thermo-mechanical recycling is possible in principle, but is limited if it is mixed with other fibres. Chemical recycling is developing rapidly and should be possible before 2025.

The vast majority of recycled polyester currently used in clothing comes from the recycling of PET plastic bottles. Its properties are very similar to those of standard polyester.



GLOBALLY PRODUCED

STRONG
ABRASION RESISTANT
CREASE RESISTANT
SUSCEPTIBLE TO PILLING



CLOTHING
UPHOLSTERY
HOUSEHOLD LINEN
CURTAINS
CARPETS
TECHNICAL TEXTILES

Long lasting properties

None

Brushed polar fleece is more prone to release small fibres and micro-plastics

Most recycled polyester used in textiles comes from PET bottles

Mechanical recycling

Thermo-mechanical recycling degrades the properties of the original material

Chemical recycling will soon be possible

Re-extrusion is compromised by reduction in molecular weight

Non-renewable raw material

Generates micro-plastics

Doesn't degrade in nature ('possible' degradation in nature after 20 – 200 years)

Commercial labels linked to specific properties (quick drying, wicking, etc.)

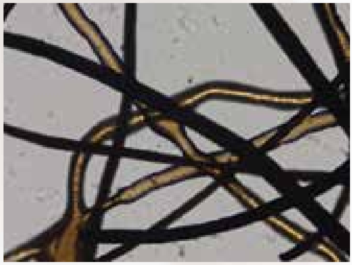
WIDE RANGE OF APPLICATIONS, FROM HIGH-PERFORMANCE SPORTSWEAR AND TECHNICAL TEXTILES TO LOW-COST FASHION

PRONE TO PILLING

POSSIBLE LACK OF COMFORT DUE TO LOW MOISTURE ABSORPTION

NEGATIVE IMAGE OF OIL-BASED FIBRES

POLYAMIDE



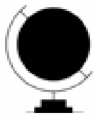
Polyamide, also called Nylon, is a polymer developed by DuPont over a 10-year period starting in 1927. It was originally developed to replace silk which was very scarce. During World War II it became very popular thanks to the production of nylon stockings.

Nylon is a generic name for a group of polymers that carry a polyamide group. There are several types of Nylon. In textiles Nylon6 and Nylon66 are most used. Nylon6 is produced from caprolactam, a chemical developed from a basic molecule gained from petrol. Nylon is melted and pushed through the spinneret to form filaments. In some cases, it is texturized to create volume.

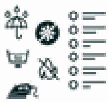
Today, nylon is used in a multitude of textile products including carpets because of its high resilience and abrasion resistance, hot air balloons, sails, parachutes, and socks.

Nylon can also be made from renewable resources. Nylon 6 is a well-known example of recycling in the textile industry (Econyl® from Aquafil). Nylon6 is relatively easy to recycle because it can be broken down into caprolactam, which can be used to make completely new nylon 6. This process is unique to nylon 6 and is not possible for other types of polyamides. They can be recycled in a more traditional way by remelting and re-extrusion.

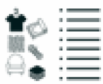
In general, polyamide is used less frequently than polyester because it is more expensive, except for carpets and rugs because of its excellent resilience.



GERMANY
USA
CHINA
SWITZERLAND
ITALY



MANY POSSIBLE SHAPES AND PROPERTIES
AVAILABLE AS FILAMENTS, FIBRES, MICRO-FIBRES
OVERALL HIGH STRENGTH AND RESISTANCE TO ABRASION
VERY GOOD RESILIENCE
NYLON6 CLOSED LOOP RECYCLING IS A REALITY



APPAREL (SPORTSWEAR)
STOCKINGS
CARPETS
LIGHT FABRICS FOR PARACHUTES, HOT AIR BALLOONS
HOUSEHOLD LINEN
UPHOLSTERY
CURTAINS

Long lasting properties

Nylon6 chemical recycling is one of the most developed closed loops recycling options for synthetic fibres. This is not the case for all other polyamides!

Another name for polyamide is Nylon

Mechanical and thermo-mechanical recycling

Existing chemical recycling supply chain for Nylon6 with Econyl® by Aquafil

Possible to recycle other types of polyamides

Non-renewable raw material

Generates micro-plastics

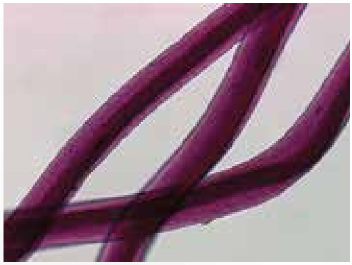
Doesn't degrade in nature

None

VERY RESISTANT

MORE EXPENSIVE THAN POLYESTER AND THEREFORE LESS USED

POLYPROPYLENE



Polypropylene (PP) is a thermoplastic polymer developed by Philips Petroleum around 1951. It is the second most widely used plastic after polyethylene. It is not commonly used as a fibre in garments. However, it is widely used in textile applications such as carpets or consumer goods (e.g. diapers) because it is one of the cheapest polymers.

Polypropylene is melted and forced through a spinneret to form filaments. In some cases it is texturised to add volume.

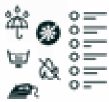
Polypropylene is the lowest density polymer commonly used in textiles, with a density of around 0.9 g/cm³.

Polypropylene isn't used at all in comfort applications (such as clothing) because of its hydrophobic nature. It doesn't feel comfortable. However, polypropylene is used in applications such as (event) carpets because its excellent resistance to fatigue. It is also used in outdoor applications provided UV stabilisers are added.

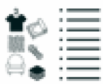
Polypropylene itself is also not flame retardant and loses strength quickly under UV (sunlight) if it isn't stabilised. As a result, additives are often used in polypropylene to make it fit for the purpose for which it is intended.

Polypropylene can be recycled. However, because virgin polypropylene is so cheap, it's not economically viable to recycle it. There are also problems with polypropylene from different sources, as each source can have its own specific molecular weight.

CHINA
USA
TURKEY
BELGIUM



100% HYDROPHOBIC AND AS SUCH USELESS FOR ALL TEXTILES WHERE COMFORT IS IMPORTANT (CLOTHING, HOUSEHOLD LINEN)



CARPETS
NON-WOVEN TEXTILES
DISPOSABLE TEXTILES
CARPETS
TECHNICAL TEXTILES
CONSUMABLES (EG DIAPERS, SANITARY PRODUCTS)

Recyclable in principle (thermoplast)

Hydrophobic fibre

No long term UV stability without additives

Thermoplastic recycling

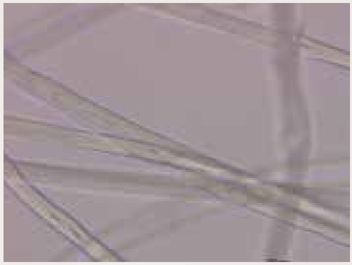
Non-renewable raw material
Generates micro-plastics
Doesn't degrade in nature

None

CHEAP

HYDROPHILIC AND THEREFORE NOT SUITED IN CERTAIN APPLICATIONS

ACRYLIC



Acrylic is a synthetic fibre made from a petroleum-based polymer called polyacrylnitrile (PAN). The fibre is known for its softness and lightness and is similar to wool. It has good thermal insulation properties, but is not breathable and does not wick moisture away from the skin. It has excellent colour fastness to washing and UV light. It is also easy to care for. It is typically used for home textiles, but also for some garments such as pullovers, socks or sportswear.

The PAN polymer and the acrylic were developed around 1950 by DuPont and ICI (and others) as an alternative to wool fibres. It is produced by solvent wet spinning. The acrylic is dissolved in a solvent such as dimethylformamide (DMF) and then coagulated in a water bath. PAN is also a precursor for the production of carbon fibres.

Acrylic textiles can be recycled into acrylic polymers mainly by thermo-mechanical recycling. However, it is important to remove as many impurities as possible, which is still difficult today.

CHINA
US
INDIA
EU

LIGHT AND SOFT TEXTURE
DURABLE AND EASY-CARE
THERMAL COMFORT
DOES NOT WRINKLE
BASICALLY NOT BREATHABLE
GOOD STRETCHABILITY AND STRENGTH

HOME TEXTILES
SOCKS
OUTDOOR CLOTHING AND SPORTSWEAR

None

Good outdoor resistance

Functionalising possible (and necessary)

Can be blended with cotton, wool and other fibres

Thermo-mechanical recycling is possible but not easy

fossil-based

No biodegradation

Formation of microplastics

None

MANY WOOL-LIKE PROPERTIES

FOSSIL-BASED
LOW BREATHABILITY

ELASTANE

Elastane is a synthetic fibre made from a polyether-polyurea type polymer. Invented by DuPont around 1958, it is commonly known by brand names such as 'spandex' and 'lycra'. Elastane filaments are produced in a complex multi-stage solvent spinning process and further processed during yarn formation.

The fibre is known for its extraordinary elastic properties, up to 500% and more. As a result, it provides a significant increase in wearer comfort for textiles worn close to the body, for normal use, sports, or medical applications. The fibre is not normally used as a "stand alone" yarn or fabric but is blended in small percentages with yarns and fabrics of other fibre types.

It has a limited ability to transport moisture but is lightweight and does not wrinkle.

Recycling of elastane into acrylic polymers is technically feasable and is done, mainly by thermo-mechanical recycling. In practice, however, its use in small proportions in mixtures and the presence of impurities make it virtually impossible.

USA

CHINA AND OTHER ASIAN COUNTRIES

EU

EXTRAORDINARY ELASTICITY
LIGHTWEIGHT
DOES NOT WRINKLE
BASICALLY NOT BREATHABLE

CLOTHING (UNDERWEAR, SWIMWEAR, JEANS)

TEXTILES FOR BODY SUPPORT AND RECOVERY (ORTHOTICS, COMPRESSION WEAR)

TECHNICAL TEXTILES

None

Blending is necessary

Functionalising is possible (and necessary)

Can/must be blended with other fibres (e.g. cotton, wool)

Very hard to recycle. Research is on-going, industrial technologies and capacities are emerging

Fossil-based

Not biodegradable

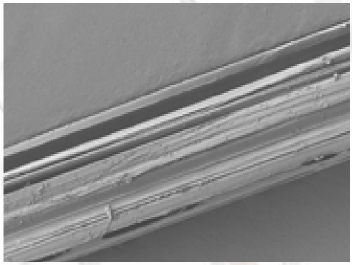
Generates micro-plastics

None

EXTREMELY ELASTIC

FOSSIL-BASED
LOW BREATHABILITY
HARD TO RECYCLE

POLYLACTIC ACID (PLA)



Polylactic acid (PLA) is a type of polyester. Developed in 1920 by DuPont it was first commercialised 20 years ago. PLA is a bioplastic obtained from fermented plants such as sugarcane.

It has a limited use in the textile industry, such as geotextiles and agrotextiles. It is a less favourable fibre for clothing because the fibre does not offer much comfort.

PLA fibres are obtained by an extrusion process where the polymer is melted at a range of 180 – 220°C and pushed through small holes of a spinneret.

The resulting filament is then stretched to align the molecules to increase strength. The filament can be used as such in a textile material but can also be cut in short-length fibres and mixed with other fibres such as cotton and spun into a yarn.

The fibre can be coloured during or after extrusion or spinning. During extrusion, coloured pellets are added to the extrusion feed. After extrusion, the fibre can be dyed via a standard dyeing process.

PLA fibres have no specifically remarkable properties.

They are mainly used because they are biobased and industrially compostable.

PLA can degrade in nature over a longer period (estimated 24 months). However, in some environments, for example the ocean, PLA does not degrade at all.

CHINA
NETHERLANDS
BELGIUM
USA

SIMILAR TO POLYESTER BUT LESSER COMFORT

SIMILAR TO POLYESTER BUT DUE TO THE LESSER COMFORT IT IS MOSTLY USED IN MORE TECHNICAL APPLICATIONS

Biodegradable under certain conditions (industrial composting)

None

Limited biodegradability

recyclable

Not biodegradable in certain environments (e.g. marine)

None

POSITIVE IMAGE

PRICE

TEXTILE PROCESSES

SPINNING

PURPOSE	Manufacturing of yarns
PRINCIPLE	Yarn spinning is the process of manufacturing yarn from fibres into a continuous thread. A defined input of fibres is blended, carded, drafted, twisted, and wound onto a bobbin, being simultaneously stretched. The most commonly used core technology is ring spinning. Others are open-end spinning, compact spinning and air-jet spinning. The material flow in modern spinning mills is highly automated. Machines and settings vary according to the length of the fibres. Short fibres, such as cotton, and long fibres, such as wool, require different equipment.
KEY CHARACTERISTICS	Yarn count (between Nm 5 and Nm250), fibre type, twist
INPUT	Fibre bales
OUTPUT	Yarn on a bobbin (up to 10kg) going to fabric production
PROCESS STEPS	Blending, opening, carding, drafting, spinning, twisting, rewinding, inspection. Also colouring, texturing and functionalisation.
MAIN RESOURCES	Facilities for opening, cleaning and blending, machines for carding, drafting, roving, spinning and twisting, material transport means, workers, electricity, compressed air, air conditioning, few chemicals, partly steam, CAD/CAM files.
RESOURCE SETTINGS	3-shift spinning mill, up to 50 spinning machines and more, each having up to 2 000 spindles and more, spindle speed up to 200 000 rpm, production capacity up to 300m/min. Facilities and machines for preparation and winding/twisting (up to 50 and more). Layout depends on fibre type. 10-50 workers.
CHALLENGES	Machine set-up time for product change at a ring spinning machine at least 1 day (and more), strongly depending on product sequence. Efficiency typically more than 95%, automatic repair of yarn breaks, automatic feeding of material. Automated cleaning avoids fibre fly.
EXAMPLES	
PRODUCTS	Yarns for all applications, partly twisted, partly dyed & functionalised
RESOURCES	Different factory settings for different fibre types
YARN/FIBRE TYPES	All (e.g. cotton, wool, PES, glass, carbon)

SUSTAINABILITY ASPECTS

- Low waste (of fibres and yarns)
- Substantial energy need
- Limited reuse of fibres and yarns
- Yarn recycling via shredding into (used) fibres, and further into polymers
- Quality & longevity depends on yarn construction and material characteristics

CRITERIA

- Fibre type, yarn count, fibre length, yarn construction
- Electricity
- Low waste
- Low gas, low chemical

EXTRUSION

PURPOSE

Production of (endless) synthetic filaments

PRINCIPLE

Synthetic polymers (in form of pellets, granulate or chips) are melted, extruded, pressed through nozzles, leading to raw endless filaments. These filaments are quenched, fixed, and then drawn and (opt.) twisted. Depending on the yarns to be produced, the filaments can be cut into fibres.

KEY CHARACTERISTICS

Polymer type, Nm, number of filaments, tensile strength, density, elongation break, elasticity, melting point, additives

INPUT

Polymer granulates, pellets, chips

OUTPUT

(endless) filaments on bobbins, up to >20kg

PROCESS STEPS

Polymer preparation, melting, extrusion, formation of raw filament with nozzles, fixation, drawing (optional), winding and cutting (optional).

MAIN RESOURCES

Spinning lines for melt spinning, wet spinning, dry spinning, and others (Attention: not to be confused with staple fibre spinning lines!), electricity, water, chemicals, machines for (re-)winding, recipe/process control file.

RESOURCE SETTINGS

A factory with up to 10 (and more) primary spinning lines, each one able to produce between 1kg/h up to more than 100kg/h. Typically working in 3 shifts, 7days/week.

CHALLENGES

Quality of nozzles, general process control (speed, temperature, ….), to be aligned with polymer type, requested filament characteristics and line configuration

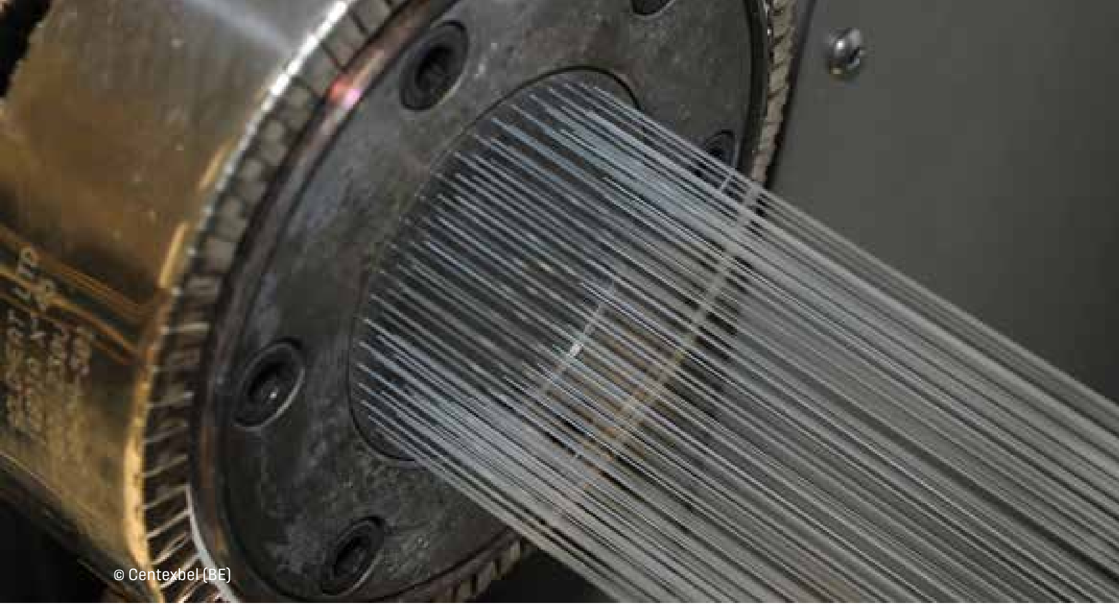
EXAMPLES

PRODUCTS

All types of synthetic fossil-based (PES, PA, PP) and bio-based (PLA) fibres, and regenerated, cellulose-based fibres (viscose, Lyocell, etc).

RESOURCES

Typically fossil-based polymers, but also more and more bio-based (PLA) polymers, and cellulosic pulp (wood).



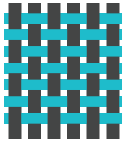
SUSTAINABILITY ASPECTS

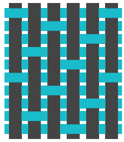
- Low waste
- Energy consumption optimisation (electricity) and water
- Recycling of synthetic filaments (and products of it) is upcoming standard, but difficult if mixed with other fibres and also with chemicals

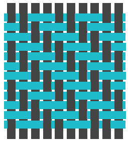
CRITERIA

- Filament characteristics and functionality
- Polymer type and source
- Medium to mass production
- Energy and water
- Chemicals

WEAVING


PLAIN WEAVE


SATIN WEAVE


TWILL WEAVE

PURPOSE
Manufacturing of woven textile fabrics

PRINCIPLE
Yarns from 2 directions (warp: lengthwise, weft: widthwise) are alternately interlaced to create a connected structure according to a design.

KEY CHARACTERISTICS
Width (cm), weight (g/m²), weave, density, weft yarns (number, type, colour) warp yarns (number, type, colour), elasticity, weaving speed (in wefts/minute)

INPUT
Threads on spools for the weft. Warp threads from spools gathered on a warp beam.

OUTPUT
(Raw) fabrics on rolls (up to 10.000m)

PROCESS STEPS
Warping, seizing & drying, beaming, set-up, weaving, inspection

MAIN RESOURCES
Warping machines, weaving mills, workers, electricity, pressured air, air conditioning, chemicals, steam, CAD/CAM files with fabric construction information

RESOURCE SETTINGS
3-shift weaving factory, between 10 and more than 200 similar weaving machines, making similar products, 10-50 workers, speed between 200 and 2000 weft/min, product types, material type and machine type are strongly interlinked

CHALLENGES
Machine set-up time for product change between 1h and 1 day (and more), strongly depending on product sequence, efficiency between (less than) 50% and 98%, dominated by yarn breaks, low automation of material flow

EXAMPLES

PRODUCTS
Flat & pile fabrics
garments, carpets, towels, upholstery, composite reinforcement

RESOURCES
Jacquard weaving, shaft weaving, etc.

YARN/FIBRE TYPES
Cotton, wool, PES, glass, carbon, etc.

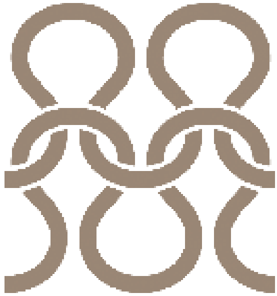
SUSTAINABILITY ASPECTS

- Low waste (of yarns and fabrics)
- Energy use
- Limited reuse of fabrics and yarns
- Recycling of fabrics via shredding into (used) fibres or further into polymers,
- Quality & longevity depends on fabric construction and material characteristics
- Relevant data /data model existing, but typically not public and case-specific

CRITERIA

- Speed
- Electricity
- Low waste
- Colours
- Low gas, low chemical

KNITTING



PURPOSE
Manufacturing of knitted textile fabrics

PRINCIPLE
Knitting is a method to produce textile fabrics by interlacing yarn loops with loops of the same or other yarns, thus creating a linked material structure, consisting of stitches. In general, a knit fabric is more elastic than a woven one. The yarn movement is performed mechanically, with full electronic automation. For clothing, knitwear is generally produced on circular or flat knitting machines, using weft knitting. Some machines allow '3D' knitting to be adjusted to the parts of the body to be covered. or decorative and technical textiles, warp knitting is predominant.

KEY CHARACTERISTICS
Width (cm), weight (g/m²), knit, gauge, yarns (number, type, colour) elasticity, knitting speed (in rows/minute)

INPUT
Yarns on bobbins

OUTPUT
(Raw) fabrics on roll (up to 10.000m), going to finishing/ functionalisation

PROCESS STEPS
Yarn preparation, knitting, inspection

MAIN RESOURCES
Knitting machines, workers, electricity, pressured air, air conditioning, some chemicals, CAD/CAM files with fabric construction information

RESOURCE SETTINGS
3-shift knitting factory, between 10 and more than 200 similar knitting machines, making similar products, 10-50 workers, speed between 200 and 2000 rows/min, product types, material type and machine type are strongly interlinked

EXAMPLES

PRODUCTS
Garments, furniture, healthcare, geotextiles, composites

RESOURCES
Flat knitting machines, circular knitting machines, warp knitting machines

YARN/FIBRE TYPES
Cotton, wool, PES, glass, carbon, etc.

SUSTAINABILITY ASPECTS

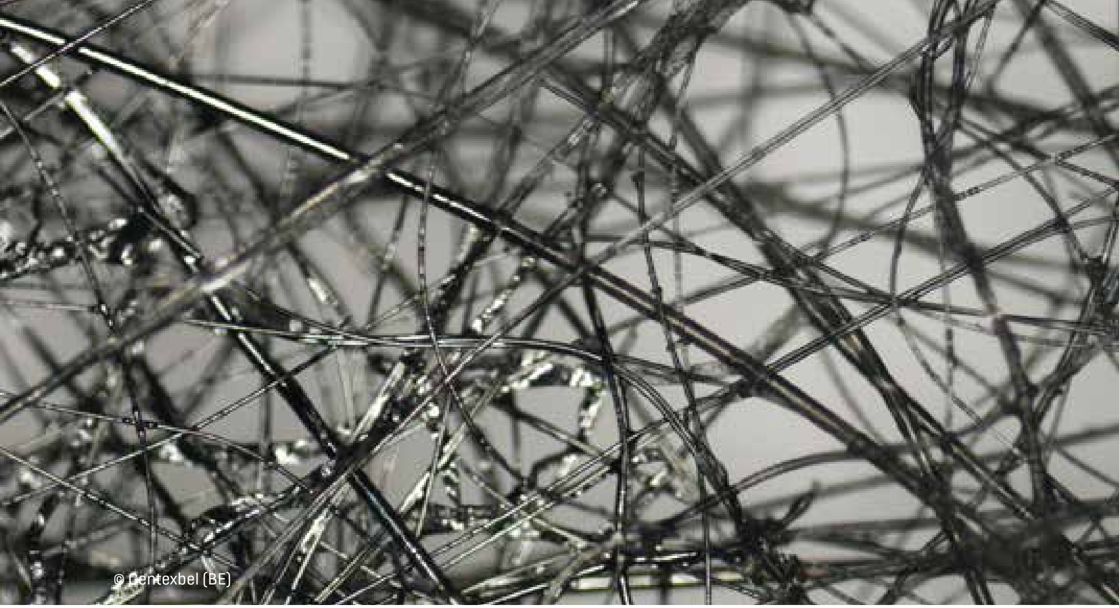
- Low waste (of yarns and fabrics)
- Energy use
- Limited reuse of fabrics and yarns
- Recycling may be possible, depending on the composition
- Quality & longevity depends on fabric construction and material characteristics
- Relevant data /data model existing, but typically not public and case-specific

CRITERIA

- Speed
- Electricity
- Low waste
- Colours
- Low chemical

WEB FORMATION

PURPOSE	Production of nonwoven fabrics
PRINCIPLE	A nonwoven is a fabric-like material made from staple and long fibres bonded together by chemical, mechanical, heat or solvent treatment in a continuous process. Such felts and other nonwovens are less strong than woven or knitted fabrics, and are typically intended for single use. Fibres are laid on a conveyor belt in the form of a sheet or web and mechanically, thermally or chemically entangled. Synthetic fibres are often used, with an increasing proportion of recycled fibres. Nonwovens come in a variety of densities and thicknesses. The main functions are water and liquid absorption, filtration and insulation. The advantage is that there is no need for yarn manufacture. Products made from nonwovens are hygienic or surgical products, filters, insulation or geotextiles. Nonwovens are also used as interlinings in clothing. There are two production principles: either (existing) fibres are bonded, or - in the case of meltblown or similar - polymers are melted, extruded into filaments, laid on the belt and then bonded.
KEY CHARACTERISTICS	Width (cm), weight (g/sqm), thickness (mm), density, strength, fibre characteristics and and composition, production speed
INPUT	Fibre bales or polymer granulate
OUTPUT	Nonwoven fabrics on rolls (up to 10.000m) going to finishing/ functionalisation
PROCESS STEPS	Fibre blending & preparation, dispersion on conveyor belt, bonding. In case of meltblown: polymer feeding, melting, extrusion and bonding
MAIN RESOURCES	Nonwoven machines and lines, workers, electricity, pressured air, air conditioning, chemicals, water, recipes for process setting, process control
RESOURCE SETTINGS	Continuously running machines and production lines, capacity even more than 100 000 tonnes per year
EXAMPLES	
PRODUCTS	Felts and webs for garments, furniture, health, construction, hygienic, filter, insulation, transport
RESOURCES	Meltblown lines, staple fibre lines
YARN/FIBRE TYPES	PA, PE, PES, PP, viscose, cotton, wool, glass, etc.



SUSTAINABILITY ASPECTS

- Low waste
- Use of recycled fibres and polymers
- Need of energy, partly water, pressured air, chemicals
- Recycling depends on compositiion
- Quality & longevity depends on non-woven construction and material characteristics

CRITERIA

- Application
- Speed
- Electricity
- Low waste
- Water
- Chemicals

TEXTILE FABRICS AND YARNS ARE MOSTLY COLOURED, WHEREAS RAW FIBRES HAVE NO SPECIFIC COLOUR.

COLOURING IS ACHIEVED BY APPLYING DYES TO THE SURFACE OR THE CORE OF THE FABRIC..

YARN DYEING RESULTS IN HIGHER QUALITY BUT REDUCES FLEXIBILITY AND INCREASES THE COMPLEXITY OF FABRIC CONSTRUCTION. IT IS ALSO POSSIBLE TO DYE FIBRES AND WHOLE GARMENTS.

DYEING TYPICALLY RESULTS IN MONOCHROME FABRICS, WHILE PRINTING ENABLES THE CREATION OF (COMPLEX) COLOUR PATTERNS.

DYEING

PURPOSE	Colouring of fabrics

PRINCIPLE

Pre-treated knitted or woven fabrics, typically uncoloured, are treated with colouring chemicals. Dyes or pigments are applied on textiles to get the desired colour and fastness, typically monochrome.

Dyeing usually takes place in a dye bath, using a precisely controlled process. The recipe depends on fibre type, fabric and targeted colour. After wet dyeing, the textile must be dried, needing energy, and the dye solution has to be cleaned and recycled.

The dyeing process is done in a dyeing vessel in a batch process, for fabric pieces, or in a continuous process on a dyeing line, often combined with other finishing processes.

Different fibres require different types of dyes, such as acid, basic, disperse, vat dyes and more. Dyes are typically man-made, based on petroleum-based chemistry. Historically, dyes have been extracted from nature and, with sustainability in mind, this is increasingly the case again, supplemented by biopolymer-based chemistry.

KEY CHARACTERISTICS	Colour (intensity, space, durability, brightness), fibre type, dye stuff, dyeing process, process settings, fabric shrinkage.
INPUT	“Ecru” and pre-treated fabrics on rolls or folded, with a typical width of approx. 1.5m
OUTPUT	Monochrome dyed fabrics
PROCESS STEPS	Pre-treatment, dyestuff preparation, batch dyeing, tumbling and drying, or continuous dyeing (incl. drying), after-treatment, quality control
MAIN RESOURCES	Dyeing machines or lines, chemicals, water, energy (electricity, steam, gas), recipes, dyestuff production (“textile colour kitchen”), colour measurement laboratory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RESOURCE SETTINGS

- Batch dyeing plant (e.g. 5-20 batch dyeing machines, each with a capacity between 10kg and 1000kg and a process time between 4h and more than 1 day, stenter frame(s))
- Continuous dyeing: 2-10 dyeing lines running at 5m/min up to 100m/min.
- Material transport is manual, dyestuff transport automatic

CHALLENGES

- Colour quality and homogeneity. Each production order has to be precisely planned, calculated, processed and controlled. Re-colouring is possible.
- Process setting strongly depend on fibre composition, fabric construction and colour
- After each colouring process the machine has to be cleaned most carefully.
- Process optimisation for minimising energy consumption
- Dyestuff management and colour selection
- Precise pre-treatment of ecru fabrics

EXAMPLES

- Dyeing of fabrics, of yarns, of fibres, of garments, of....
- All fibre types and textile constructions can be dyed
- Machines, dyestuff, process settings and colour (sequence) are strongly linked.

SUSTAINABILITY ASPECTS

- Almost no textile waste
- High energy consumption (for drying processes)
- Dyeing chemicals, typically fossil-based, but increasingly from bio-sources
- Chemical waste is (often) recovered
- Water cleaning
- High colour fastness requests good processes

CRITERIA

- Colour (type, space, intensity, fastness, ...)
- All fibre types and fabric constructions
- Dye stuff
- Medium series to mass production
- Energy and water

PRINTING

PURPOSE	Colouring of fabrics

PRINCIPLE

Dyes or pigments are applied on a fabric surface in a structured way, resulting in (complex) colour patterns and designs.

In **SCREEN PRINTING**, the dye or ink is forced through a mesh screen, which is a stencil of the desired pattern. By using, for example, 8 different inks and overprints, a very wide range of designs and colours can be achieved. Screen printing is best suited to short runs. In rotary screen printing, the stencil is fixed to rotating cylindrical screens and the ink is applied to the fabric as it moves (and rotates). Up to 24 screens per machine are typical. Rotary screen printing is best suited to mass production, with speeds in excess of 100m/min. Design and colour changes are affordable.

DIGITAL TEXTILE PRINTING is much more flexible because there is no need for a stencil. The ink is pressed through very small nozzles that are digitally controlled. It can be used for one-offs, small runs and mass production. It requires precise adjustment and preparation of fabric, printer, print head and ink. Production speeds range from 0.1m/min to 200m/min, depending on the printer, colour range, quality and more.

The ink composition is highly dependent on the type of fibre type, and fabric and on the desired colour. A variant of digital textile printing is to apply the ink on a transfer paper and then transfer it to the fabric. After printing, a fixation process is required, which consumes energy. Energy and water are used to clean the machines. Inks can be recycled.

Different fibres require different inks, such as pigment inks or reactive inks, which are typically based on fossil fuels. Historically, dyes have been extracted from nature and, with sustainability in mind, this is increasingly the case today. Bio-polymers for dyeing are also emerging.

KEY CHARACTERISTICS	Colour, fibre type, ink, printing process, process settings, fabric shrinkage
INPUT	"Ecru" and pre-treated fabrics on rolls or folded, with a typical width of approx. 1.5m. For digital textile printing no limitations
OUTPUT	Printed and coloured fabrics or products.
PROCESS STEPS	Pre-treatment, screen preparation, recipe calculation, ink & dyestuff preparation, printing, drying & fixation, quality control
MAIN RESOURCES	Printing machines or lines, chemicals, water, energy (electricity, steam, gas), recipes/print file, ink production ("textile colour kitchen"), colour measurement laboratory
RESOURCE SETTINGS	▪ Digital textile printing shop floor (e.g. from below 5 up to more than 20 printing machines or digital textile printing lines ▪ Rotary screen printing: 2-10 printing lines, running with 10m/min up to 100m/min (and more) ▪ After-treatment for drying and fixation ▪ Material transport is often manually, ink transport is done automatically

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CHALLENGES

- Colour quality. Each production order has to be precisely planned, calculated, processed and controlled. Re-colouring difficult
- After each colouring process the machine has to be cleaned most carefully
- Energy consumption
- Ink management and colour selection
- Precise pre-treatment of fabrics necessary

EXAMPLES

- Printing on fabrics, yarns, fibre, garments are basically possible, with appropriate machines
- All fibre types and all textile constructions can be coloured
- Machines, dyestuff / inks and material are strongly linked
- Not only colours can be (digitally) printed, but also functionalities like water repellence and more

SUSTAINABILITY ASPECTS

- No textile waste
- Digital textile printing perfect for individual prints or for sampling, but needs precise setting
- Screen printing requires stencils with the desired pattern
- High energy consumption (for drying processes)
- Inks and colouring chemicals are needed. Waste is recovered. More and more use of bio-polymers
- Water for cleaning needed
- High colour fastness requests good processing

CRITERIA

- Colour (type, space, fastness)
- Fibre composition
- Dye stuff and inks
- Energy and water
- Print head (for digital printing), stencil for screen printing

TEXTILE FUNCTIONALISATION

Textile functionalisation is the process of adding new functions, features or properties to a textile material by modifying its surface chemistry to meet the requirements of the final application.

New functions, features or properties include comfort, breathability, waterproofing, thermal regulation, antimicrobial properties, easy care, durability, flame retardancy, and the overall mechanical performances of textiles.

Between 2015 and 2020, the functional textiles sector has known a compound annual growth rate (CAGR) of 30%, driven by automotive, fitness, fashion, healthcare, military and sports textiles.

ANTIMICROBIAL FINISHES

Due to their large surface area and strong ability to retain moisture, textiles provide an excellent environment for micro-organisms, especially for bacterial growth. The growth of harmful bacteria on textiles leads to unpleasant odours and is a major health concern.

Pathogenic bacteria on the fabric surface can cause severe skin infections such as skin allergy and irritation via direct human contact.

Antibacterial textiles are able to kill or inhibit the growth of bacteria and are therefore an important class of functionally active textiles. Coatings based on nanoparticles are widely used in both natural and synthetic textiles. Silver is one of the most commonly used compounds in this area.

Other metals including titanium, tin, zinc, gold and copper are applied on various natural and synthetic fabrics.

Many natural active agents are extracted and used to develop antibacterial fabrics. Plant extracts, essential oils and animal-derived products are used in fabrics to treat wound infections.

Several natural dyes, pigments and mordants have also been explored for their antimicrobial activity.

Natural halogenated compounds are used in fabrics to provide antimicrobial properties.

FIRE-RETARDANT FINISHES

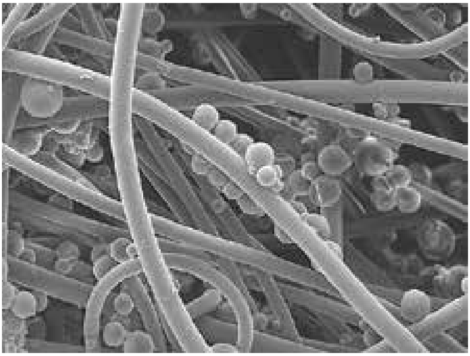
Due to their organic structure, most textiles are flammable and several factors affect this flammability: fibre type, yarn structure, fabric structure and any chemicals/coatings applied to the fabric.

Textiles and upholstery are the first to be ignited by small flames from heat sources, such as cigarettes and candles, so the flammability of textile materials is a safety concern.

Flame retardant textiles are therefore an important class of materials as they are used in a wide range of applications, from clothing to technical textiles such as military, automotive and aerospace applications, as well as safety and protective clothing.

Conventional fire retardant compounds are manufactured synthetically. Due to current environmental issues, there is an urgent need to develop ecological fire retardant products.

Naturally derived compounds, namely various types of bio-based phosphorylated polysaccharides such as chitosan, alginate etc., some natural inorganic compounds such as silica and alumina and some other compounds such as phytic acid, casein, lignin and tannic acid terephthalate are also being considered in some recent studies for their potential fire-retardant properties.



CREASE RESISTANT FINISHING

Most cellulosic fabrics and blends of cellulose-rich fabrics tend to crease or wrinkle. Synthetics, such as polyester or nylon, have a natural resistance to wrinkling.

Crease resistance, also known as wrinkle resistance, provides the fabric with the ability to resist the formation of creases or wrinkles, thereby providing a better appearance.

Crease resistance is achieved by cross-linking the cellulose chains to prevent the molecules from moving when in contact with water or other environmental stresses. Special resin coatings (such as phenol-formaldehyde resins, urea-formaldehyde resins, alkyd resins, ketone resins, vinyl resins) impart this wrinkle resistance to the textile products.

The use of formaldehyde resins has been found to be hazardous and has other limitations as it can make the fabric stiff or uncomfortable. The use of catalysts, such as titanium dioxide (TiO_2), could minimise the formation of free formaldehyde and the loss of strength of the fabrics when applying wrinkle resistant finishing treatments by using resins. Nanomaterials are also used as another alternative to conventional products.

WATER AND STAIN REPELLENT FINISHES

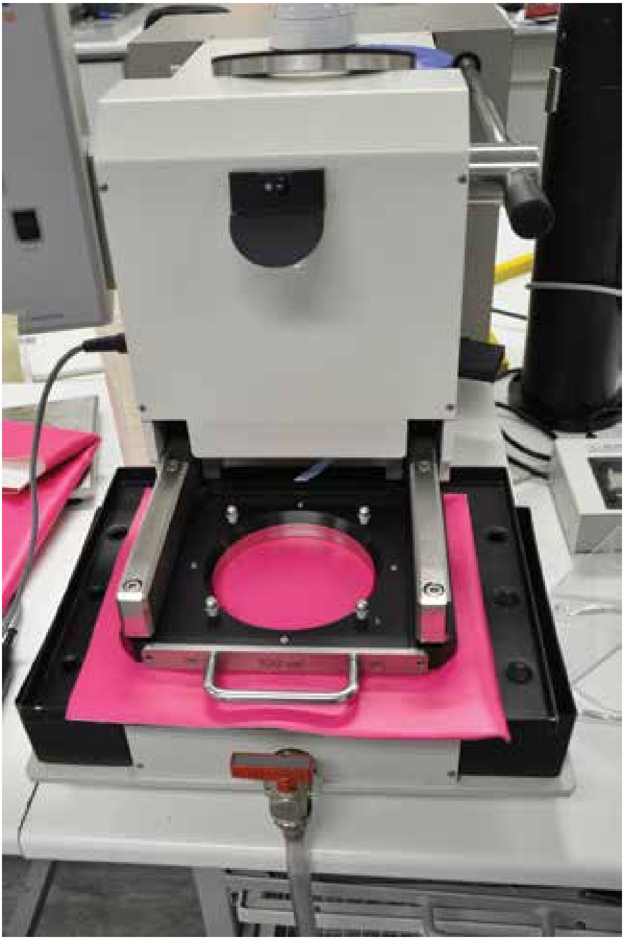
Water and stain repellency are two types of functionalities that are of great importance for textile applications. Textile products such as baby clothing, upholstery and corporate wear have a great interest in these finishes.

The combination of water and oil repellency is a typical behaviour of fluorocarbon based products. In the past, finishes based on C8 fluorocarbons were mainly used.

Concerns have been raised about these C8 fluorocarbons, particularly PFOA (perfluorooctanoic acid) and PFOS (perfluorooctane sulfonate). The trend is to replace C8 fluorocarbon chemistry with C6 or C4 fluorocarbon products or even fluorine-free water repellents.

However, short-chain fluoropolymers are less efficient, do not degrade easily and are still hazardous to humans and the environment. Other options such as long alkyl chains could be an alternative to fluorocarbons. Long-chain fatty acids such as stearic acid and palmitic acid are bio-based and can impart water repellency by modifying the surface of cotton fabrics, but they are much less effective than fluorocarbons.

MOISTURE MANAGEMENT FINISHES



Moisture management finishes enhance the ability of textiles to absorb moisture from the skin, transport it efficiently to the outer surface of the fabric and release it to the surrounding air. This is an important fabric property that determines comfort.

Properties such as wetting, wicking and moisture vapour transmission are critical in assessing the performance of products with moisture management finishes.

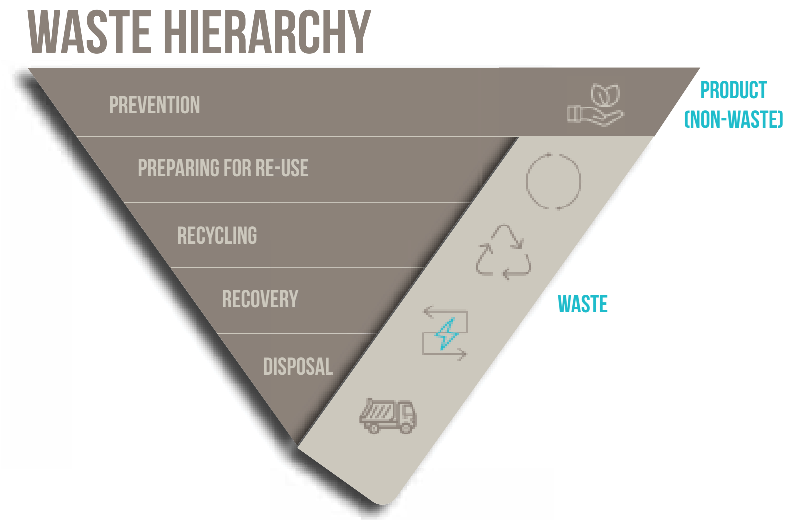
Optimal moisture management - high wicking speed and drying rates - can be created by adding hydrophilic properties to textiles through fibre or fabric modifications and garment design.

On the fibre side, adding hydrophilic chemicals during spinning or using special cross sections to create capillarity resulting in high wicking and drying rates are options used to promote moisture management. Natural fibres tend to be hygroscopic and have longer drying times. Hydrophilic softeners, finishes or coatings can be applied to fabrics.

In garment design, multilayers of hydrophilic and hydrophobic fabrics can be created to improve moisture transport and comfort.

RECYCLING

CLOSED LOOP VS. OPEN LOOP



Recycling is not the first solution to solve waste problems. According to the EU waste hierarchy, recycling comes after prevention and reuse.

However, for a number of end-of-life products, it is the only available solution, hence its current strong growth, both in volume and technological development.

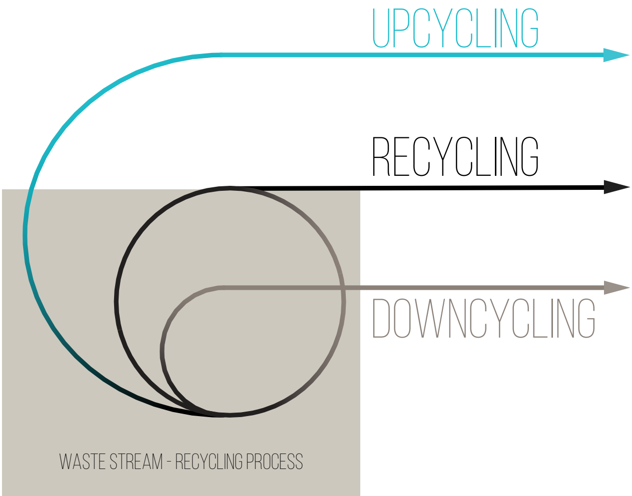
The term "recycling" refers to the transformation process aimed at reintroducing the materials used in a product into a new production process and thus into a new life cycle.

During the recycling process, textiles must be transformed back into fibres or even polymers, depending on the purpose of reuse.

CLOSED-LOOP RECYCLING means that products are recycled and processed into the same product from the same industry or production system. For example, a garment is recycled into fibres and yarns to produce new garments. It can also mean cascading recycling, where a recycled product returns to the same original production facilities but is destined for a secondary product line due to its inferior quality.

OPEN LOOP RECYCLING refers to the recycling of end-of-life products or waste products in different production processes of various goods in different sectors. This approach can lead to diversification of market niches. If several companies are involved, it is called industrial symbiosis. This is the case, for example, with PET bottles, which are recycled into polyester for use in textiles.

DOWNCYCLING VS. UPCYCLING



DOWNCYCLING refers to recycling into products of lower quality or value than the original.

In general, recycling processes undergo downcycling due to physiological factors. The continuous reduction in quality and value prevents the ability to recycle a material consistently. For example, in mechanical recycling of fibres, it is not possible to obtain extremely fine yarns, even with the addition of a high proportion of virgin fibres.

Chemical recycling can also lead to downcycling, e.g. shortening polymer chains leads to a deterioration in mechanical performance.

UPCYCLING refers to a process whereby a discarded product is converted into another product with better quality or higher value than the original product.

Garments can be reconditioned and transformed into new high-value products, creating a new product life cycle. This process starts at the design stage, has positive effects on the entire life cycle, but it requires the involvement of several players.

CRADLE-TO-CRADLE is an approach that designs any type of waste as "raw material" for new cycles, technological or biological. The goal for industry is to preserve and enhance nature's ecosystems and biological cycles, while maintaining production cycles, in a kind of "technological metabolism" where all materials must return to industry for reuse after use, avoiding or minimising downcycling.

RECYCLING PROCESSES

MECHANICAL processes involve obtaining fibres from shredding fabrics and reintroducing them into spinning or other textile processes (e.g. non-woven). In general, all fibre types are processable, but the process does not allow hard components (such as buttons, fasteners, or pieces of metal), while coatings may invalidate the process. Membranes and coatings are also incompatible with this method of recycling.

A THERMOMECHANICAL process is also widely used to recycle thermoplastic materials, including plastic bottles and some polyester fibres. Plastic waste is cut into small flakes that are melted and extruded to form filaments to produce yarn. The quality depends on several factors. In general, recycled thermoplastic fibres have lower properties than virgin fibres.

CHEMICAL recycling processes, on the other hand, focus on chemical properties and are thus directly related to the type of fibre or, in some cases, the type of blend.

For waste consisting of a 100% single fibre, it is better to use mechanical or thermomechanical recycling that are less impactful than chemical recycling: chemical recycling requires more energy and may have a larger environmental impact due to chemicals used in the production process.

A number of technologies have recently been developed, and the trend is continuing. We may expect a growth in the number of available chemical recycling facilities.

Main developments:

- chemical processes for man-made fibres with low environmental impact
- chemical processes for natural cellulosic and protein fibres (wool and silk)
- biological processes, such as use of enzymes to break down specific polymers (both natural and synthetic)

PREPARATION

SORTING
CLEANING
DISMANTLING
SHREDDING

The preparation phase is particularly important because textile waste (especially post-consumer) is composed of various fibres. Textile waste often contains all kinds of non-textile accessories and a variety of finishing additives.

These factors reduce and even prevent their recyclability for the process requires homogeneous material batches, where all elements that may affect recycling are removed and incompatible chemicals are eliminated or reduced.

SORTING to obtain homogeneous material batches from non-homogeneous waste streams. Textiles are sorted according to fibre composition or colour, but the sorting step can also include the detection of chemicals (e.g. flame-retardants, water-repellent additives, etc.). Sorting is a manual process but is evolving towards automation, and is increasingly relying on spectroscopy to determine the precise material composition.

CLEANING to remove chemicals (contaminated or finishes) that can reduce the efficiency of the process or even invalidate it (in case of presence of hazardous substances).

DISMANTLING (or disassembling) is particularly useful for complex products. First and foremost, it consists of removing the various accessories and hard elements such as buttons, zips, buckles, rivets, etc., and more generally anything that could disrupt or prevent recycling. Ut is still essentially a manual process, but it is moving towards automation.

SHREDDING is the first step in the recycling of textiles (both pre and post consumer). The textiles are opened to obtain a fibre that can be reintroduced into traditional processing cycles. The main problem is downcycling, as fabrics are subjected to a harsh action and fibres tend to shorten.

GARMENT MANUFACTURING

Garment manufacturing can be described as assembling different pieces of fabric and adding accessories. In reality, however, there are many more important steps involved than just sewing.

As with many other activities, the preparation, method, knowledge, experience and talent of those involved will be key to achieving the expected results and ensuring the right level of quality.

FABRIC PREPARATION

Fabric preparation is essential and should be given the time and attention it deserves.

Many fabrics are under tension during the production process, including weaving, dyeing, brushing, finishing and winding. It is therefore advisable to allow the fabric to relax before starting the manufacturing process. For small quantities, this process can be as simple as placing the fabrics on relaxation racks.

MARKING

Marker planning precedes the (manual) cutting step. All parts needed to assembly the product are shown in full size and positioned according to the fabric's grainline and other considerations such as the presence of defects, wavy selvedges, etc.

The way the marker planning is executed can have a major impact on fabric consumption. A few percentages saved at this stage can help reducing the cost of the product and use of resources.

SPREADING AND CUTTING

Regardless of the needed fabric quantity, the fabrics should be cut on a large cutting table, after the relaxed fabric has been spread. The fabrics must be laid with care to avoid pleats, fabric waving, and other issues that could disrupt the cutting operation. At this stage, major fabric flaws can still be detected and removed.

Depending on the quantities, the number of plies, and/or the type of material, the fabrics are either cut with scissors, a circular cutter, or with an automated cutting system (blade or laser).

Precision is key to ensure the final product will meet the product specifications.

SEWING / STITCHING

Assembling garments is often less obvious than it seems. The necessary operations can require several types of sewing machines, fusing machines, buttons or snaps attachment equipment, etc.

Depending on the complexity of the product, the skill of the operators, the machines, the total time to make a product can vary considerably. A workshop with 2 people and reduced technical potential will not operate in the same way as one with 1.500 operators equipped with state-of-the-art machines.

Depending on the type of fabrics (e.g. a stretchy knit jersey and a stiff woven denim), on the type of assembly and seam (hemming on a tee-shirt or inseam on jeans), the desired aspect, the strength needed, etc., different types of machines should be used to deliver the best possible result. The most important categories are:

- Lock stitch machine
- Double chain stitch machine
- Overlock machine
- Buttonhole machine
- Label sewing machine

Most machines are available in various set-ups. One, two or three needles, with or without folder, equipped or not with trimmers, programmable or not, semi-automatic, etc.

PRODUCT FINISHING

Once the products are sewn, there can be still several operations needed before sending them to stores, for example, measuring, pressing or ironing, washing, printing, checking and packing.

MAINTENANCE

The washing of textile products serves many purposes and can have a real impact on the lifespan of clothes, the comfort of using textiles, the protection they offer, etc. In addition, the type of washing chosen and the frequency of washing can have a significant impact on the environmental impact.

In addition, the type of washing chosen and the frequency of washing can have a significant impact on the environment.

TYPES OF WASHING

The most common type of washing is household washing, either at home or in a launderette. This can be supplemented by machine drying.

It is possible to use other types of cleaning, depending on the type of garment or textile product and their destination. For example, the various uniforms used in hospitals will be cleaned and possibly disinfected by professional laundries and in machines developed for the industry.

Dry cleaning is an option for products that cannot be washed in water, or for treating certain types of stains (grease, etc.).

CARE INSTRUCTIONS

On care labels, washing recommendations are represented by symbols, in a specific order: washing, bleaching, drying, ironing and dry cleaning

WASHING | BLEACHING | DRYING | IRONING | PROFESSIONAL CARE

Guides to these symbols can easily be found on the internet. However, some general rules can be followed:

- The washing temperature indicated is the maximum washing temperature. A lower temperature may therefore also be appropriate.
- The crossed-out symbols indicate prohibitions. It is important to respect them in order not to damage the products.

In general, these symbols are supplemented by instructions in text form. These can help to maintain the performance of the products, such as protection against rain or to maintain visual effects (abrasion marks, etc.), preserve prints, etc.

In addition to the information available on garment labels, in the form of symbols and instructions, detergent manufacturers specify on their packaging conditions of use in terms of quantity (depending on the degree of soiling) and washing temperature. Most major brands have developed detergents that are effective at low temperatures (e.g. 30°C).

PRODUCER RESPONSIBILITY

The care conditions depend on the type of product but also on the quality, the properties of the product and the materials used. Some T-shirts can be washed without problems at 60°C and dried in the washing machine, while others must be washed at 30°C and air-dried. Products for which the only option is dry cleaning may be less attractive to users because of the constraints and costs involved.

It is therefore important to define precise specifications during development. Washing tests can be carried out on the delivered products to check their behaviour under the prescribed washing conditions.

To enable users to care for their textiles correctly, producers should provide complete and correct information, using symbols and additional instructions if necessary.

HOUSEHOLD WASHING

Laundry machines continue to evolve in their design and programming. There are many machines on the market with capacities of 8 kg (previously 5 kg), and the programming favours lower water consumption and less mechanical action on the textiles.

INDUSTRIAL WASHING

As a rule, industrial washing is reserved for laundry used in various professional circuits. Whether it is uniforms used in hospitals or factories, towels and sheets from hotels, industrial laundries will apply different treatments, from a simple wash/iron to cycles including a disinfection phase.

The machines used can handle large quantities, both for washing and for drying, which can be done in a drum dryer or in a 'tunnel' dryer. Depending on the products, ironing/pressing can be done by means of calender machines (roller system for large flat surfaces such as bed sheets), ironing tables of various shapes, steam finishing tunnels, etc. This equipment, which is specifically designed for industry, requires significant heat production, particularly in the form of steam. They may also have dust or steam extraction systems.

PROFESSIONAL CARE: DRY CLEANING

In dry cleaning, water and detergents are replaced by a solvent that will essentially dissolve the grease, without penetrating the fibres. The machines, quite similar to industrial washing machines, allow the solvent to be recycled and reused. For larger stains, manual pre-treatment is often applied.

The most commonly used solvent is perchloroethylene. Perchloroethylene is classified as 'harmful to health' and 'dangerous for the environment' by the European Union. The development of new installations is increasingly being slowed down or even prohibited.

ECO-LABELS

Labels are a tool for producers/distributors/retailers to provide unambiguous evidence of the characteristics of their products, allowing consumers to clearly identify and compare products.

Eco-labels are a range of tools designed to provide consumers and users with information and guarantees about the environmental properties of products.

THE MAIN OBJECTIVE OF ECO-LABELS IS TO ENCOURAGE:

- Consumers to choose low-impact environmental goods.
- Companies to offer labelled products
- Designers to apply eco-design principles
- Marketing by improving the image of a product as a strategy and to distinguish it from non-certified products.

The International Organisation for Standardisation (ISO) has classified environmental labels into three types:

Type I Ecolabel (ISO 14024) is a voluntary scheme that officially identifies and certifies that certain products or services, throughout their life cycle, have a reduced impact on the environment. Eco-labels are awarded by an independent third party acting as Certification Body.

Type II Ecolabel - Self-declared environmental claims (ISO 14021) refers to an environmental claim (logo or text) supported by the manufacturer relating to a life cycle stage or a particular aspect of a product ('biodegradable', 'recyclable', etc.).

Type III Ecolabel - Environmental Product Declarations (ISO 14025) is a standard for comparing different products, taking into account the most significant environmental aspects and showing objective and verifiable information on the environmental aspects

OEKO-TEX®

OEKO-TEX® is an independent testing and certification system for textile products for all types of production through the textile control chain. Established in 1992, it is the world's most widespread and well-known eco-label for textile products and accessories and contributes to high and effective product safety for consumer protection.

- STANDARD 100 is the certificate which guarantees that labelled textile products are safe from a human-ecological aspect. The standard provides for verification criteria and limit values that are more demanding than the parameters established by mandatory international standards and envisages 4 product classes subdivided according to the intended use of the textiles and products in which the human-ecological requirements to be met are more stringent: articles intended for children (Class I), articles in close and prolonged contact with the skin (II), products not in contact with the skin (III); furnishing/decorative materials (IV)
- STEP (Sustainable Textile Production) is an independent certification system for brands, retailers and manufacturers within the textile supply chain who wish to communicate their commitment to sustainability to customers and other stakeholders in a simple and transparent way. With a modular structure, it allows a holistic analysis of aspects of sustainable textile production, and includes aspects such as: Chemicals management; Environmental performance; Environmental management; Social responsibility; Quality management; Work safety.
- ORGANIC COTTON is a certification for all textile products consisting of at least 70 per cent organic cotton and is based on three aspects: traceability from farm to product; a declaration on the presence of genetically modified cotton (GMO); and a set of tests to verify the absence of harmful substances, including pesticides.
- MADE IN GREEN is a traceable product label for all types of textiles and leather products that verifies that an item has been tested for harmful substances and that it has been manufactured using sustainable processes under environmentally friendly and socially responsible working conditions.
- RESPONSIBLE BUSINESS is the OEKO-TEX® certification regarding due diligence in the textile and leather industry, and covers the topic of human rights and environmental responsibility in their global supply chains in accordance with the Sustainable Development Goals.

The certification is structured in seven sections: company policy, risk assessment, integration of appropriate actions, continuous monitoring, transparent communication and complaint mechanism and climate actions.

CRITERIA

Third party certification

Criteria are public

Environmental aspects

Social conditions

EVALUATION

science-based criteria

annual update of limit values

OWNER

OEKO-TEX® Association

SWITZERLAND

WEBSITE

www.oeko-tex.com

GOTS - GLOBAL ORGANIC TEXTILE STANDARD

GOTS is the world's leading textile processing standard for organic fibres, which includes ecological and social criteria, and is based on independent certification of the entire textile supply chain. It aims to reduce the use of many chemical substances.

GOTS has a clearly defined set of criteria and is transparent, and the quality tests are well-defined and public.

GOTS certified products may include fibre products, yarns, fabrics, clothes, home textiles, mattresses, personal hygiene products, and more.

According to GOTS "there are two types of certification documents:

- Scope Certificates (SCs) which prove that a supplier meets all criteria to be allowed to process GOTS goods and
- Transaction Certificates (TCs) which prove that the goods themselves meet all GOTS product criteria."

GOTS provides two label grades, that only differ in the minimum percentage of "organic" and "organic in-conversion" material in the certified product.

CRITERIA

Third party certification

Organic fibres

Ecological and social

All processing stages

Presence of harmful chemicals

Criteria are public

Environmental aspects (energy, water, etc.

EVALUATION

Very challenging label focused on environmentally friendly products

OWNERS

Organic Trade Association (**USA**) - Internationaler Verband der Naturtextilwirtschaft (**GERMANY**) - The Soil Association (**UK**) - Japan Organic Cotton Association (**JAPAN**)

WEBSITE

www.global-standard.org

BLUE ANGEL

The Blue Angel has been the ecolabel of the German Federal Government for more than 40 years. It identifies environmentally friendly products and services.

The Blue Angel is a voluntary, market-based environmental policy tool.

It is a "Type I environmental label" in accordance with DIN EN ISO 14024.

On the basis of scientific publications, its own studies and market research, the Federal Environment Agency (UBA) establishes specific requirements for product groups (so-called award criteria) as a prerequisite for certification with the eco-label.

The following criteria are taken into account:

- resource-efficient production (water, energy, (recycling) materials)
- sustainable production of raw materials
- absence of harmful substances in the product
- reduction of emissions of harmful substances into the soil, air, water and indoor environment
- reduction of noise and electromagnetic radiation
- efficient use, e.g. energy- or water-saving products
- durability, reparability and recyclability, good serviceability
- compliance with international occupational health and safety standards
- take-back systems and shared-use services, e.g. car-pooling.

The Eco-label can currently be awarded to around 100 product/service groups in the following sectors: paper products, building products, furniture, clothing, washing and cleaning products, cleaning services, (household) chemicals, packaging/disposal, vehicles/mobility, energy/heating, (household) electrical appliances, information and communication technology, others.

More than 20,000 products from over 300 product types are certified. The eco-label is only awarded to non-food products. The label is awarded by the independent German non-profit organisation RAL gGMBH and supervised by the JuryUmweltzeichen.

CRITERIA

Independent certification body evaluation

Criteria are public

Entire lifecycle

Recyclability or recycled content

Environmental aspects (energy, water, ...)

Health protection

EVALUATION

High standards for environmentally friendly products

OWNER

German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

GERMANY

WEBSITE

www.blauer-engel.de/en

BLUESIGN®

bluesign® is a sustainability label for the manufacturing of textiles that takes particular account of aspects of chemical safety. The bluesign system unites the entire textile value chain to reduce impact on people and the planet. It has more than 20 years of experience in the textile industry, focused on sustainable chemistry.

Products that are processed to at least 90% in factories certified by bluesign may bear the "bluesign product" seal. The "bluesign® approved" seal is awarded to chemicals and components used, should they meet the requirements of bluesign®. The development of and compliance with the standards is monitored and overseen by an "advisory board" consisting of scientists and sustainability experts.

Clothing that has been produced in compliance with the standard may have a sewn-in seal or otherwise indicate that the bluesign standard has been applied. The assessment covers the entire manufacturing process of textile products and also establishes criteria regarding the chemicals used.

bluesign® has a partnership system service package that is designed for brands who truly understand the power of reducing environmental impact. They provide services, a dashboard, and an impact assessment report.

The bluesign® standard is used in Europe, Asia and North America.

CRITERIA

Presence of harmful chemicals

Private label

Environmental aspects (energy, water, ...)

EVALUATION

sustainable chemistry

OWNER

bluesign technologies ag

SWITZERLAND

WEBSITE

WWW.BLUESIGN.COM

EU ECOLABEL

The EU Ecolabel is the official European Union voluntary label for environmental excellence, certifying products with a guaranteed, independently verified low environmental impact. It was established in 1992 and is recognised across Europe and worldwide. EU Ecolabel products: minimise waste, pollution and CO_2 emissions; restrict the use of hazardous chemicals; use energy, water and raw materials wisely; are long-lasting, easy to repair and recycle; promote green innovation.

To use this label, goods and services should meet high environmental standards throughout their entire life cycle: from raw material extraction through production and distribution to disposal.

EU Ecolabel criteria are based on the best products available on the EEA market in terms of environmental performance throughout the life cycle and correspond indicatively to the best 10-20 % of the products available on the EEA market in terms of environmental performance at the moment of their adoption.

Regarding Clothing and Textiles, the EU Ecolabel for textile products guarantees a more sustainable fibre production, a less polluting production process, strict restrictions on the use of hazardous substances, and a long-lasting final product.

The ecological criteria for awarding the EU Ecolabel for textile products are included in the "Commission Decision of 5 June 2014 establishing the ecological criteria for the award of the EU Ecolabel for textile products".

Expressed in figures, 2,270 authorisations covering 87,485 products (goods and services) have been granted in the EU market up to September 2022.

CRITERIA

Environmental impacts & technical performances of product; Substitution of hazardous substances; Supports durability, reusability, recyclability and recycled content of products; Fitness for use requirements; Compliance with existing EU legislation

EVALUATION

Structured label focused on environmental claims

OWNER

European Commission (and EU Member States)

BELGIUM

WEBSITE

www.ecolabel.eu

GRS AND OTHER TEXTILE EXCHANGE STANDARDS

Textile Exchange is one of the most important international non-profit organisations promoting responsible and sustainable development in the textile sector.

The organisation also promotes sustainable practices through a variety of certifications covering environmental and social aspects.

The most important are:

- OCS (Organic Content Standards), related to organic agricultural production;
- RWS, RMS, RAS and RDS are standards for responsible production of wool, mohair, alpaca and down.
- RCS (Recycled Claim Standard) and GRS (Global Recycle Standard) are third-party verified environmental claims that guarantee the recycled content of their products, both intermediate and finished.

The scheme is based on traceability throughout the production process, providing restrictions on the use of chemicals and compliance with environmental and social criteria at all stages of the production chain.

The scheme covers products and/or manufacturing activities and guarantees:

- Products containing at least 5% (RCS) or 20% (GRS) pre- and post-consumer recycled material;
- The manufacturing processes involved in the production of intermediate products (e.g. yarns and fabrics) or finished products use management models and procedures that comply with the established requirements.

The standards do not cover waste collection, sorting, selection and grouping.

WEBSITE

https://textileexchange.org/

MEASURING DURABILITY

WHAT FACTORS DETERMINE THE LIFESPAN OF A TEXTILE PRODUCT?

We've all seen the appearance of tiny fibre knots or balls on a seat cover or jumper, even after a few uses. This is a visible form of wear and tear of the material, which is then quickly discarded. Another classic example is the visible discolouration of a carpet that can be observed when moving a wardrobe.

Textile materials can be tested in different ways, depending on the application in which they will be used. The results of these tests tell us something about the expected lifespan of the textile product.

On the following pages you will find an overview of the most important tests and the materials or applications for which they are relevant, focusing on the most common tests and applications.

The expert-approved test methods are documented in European and international standards.

The strength of a textile material is obviously an important parameter. If the slightest snag causes a tear, this can considerably reduce the textile's lifespan.

Strength comes in many forms, because a textile material can be torn in many different ways. For example, a textile material with high tensile strength will not necessarily be difficult to tear. Many parameters come into play.

TENSILE STRENGTH

Tensile strength can be measured by pulling a pre-cut sample by its ends. The force required to cause the tear is noted.

Many manufacturers use a tensile test in which a 5 cm wide specimen is torn using a tensile testing machine.

The force, expressed in Newtons (N), at which the material breaks or cracks is a measure of the strength of the material. Of course, the stronger it is, the better it is.

The strength also depends on the weight and quality of the textile material: for example, polyester is generally more tensile strength than cotton - for the same weight of material, of course.

FABRIC TENSILE STRENGTH TEST

There are two methods to test a fabric's tensile strength:

STRIP TEST:
the full width of the specimen is gripped between gripping jaws and stretched.

GRAB TEST:
only one inch of the specimen width is gripped by fixed and movable gripping jaws.

TEAR STRENGTH

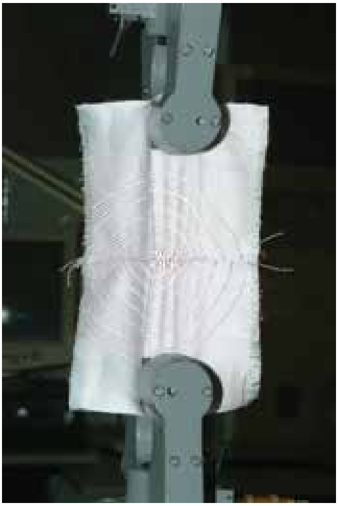
In addition to tensile strength, the tear strength is usually determined.

The spacing of the threads in the fabric plays a very important role. A textile material with tightly packed threads tears more easily than one with a certain distance between the threads. In the latter case, the threads come together in a bundle of threads that is harder to tear. When the wires are tightly packed, they are torn apart wire by wire, which is obviously easier.

Determination of the tear strength is done in different ways, but the most common is the pendulum (Elmendorf) method. The pre-cut textile is placed in a machine with an arm attached to an axis that exerts a force that causes the tear to occur. The force required to achieve this is noted.

This test is used to assess woven fabrics. It is not suitable for knitted fabrics.

SEAM STRENGTH



Garments are joined by seams. In general, the seam is weaker than the textile material. To assess the strength of the seam, the ends of two textile materials sewn together are inserted into a tensile testing machine and slowly pulled apart until the seam opens.

The force required to achieve this, again in Newtons, is the measure of the seam strength.

The methods described above cannot be applied directly to knitted fabrics. This is due to the particular structure of a knitted fabric. In a fabric, the threads are parallel to each other and the weft threads are perpendicular to the warp threads. This is not the case with a knitted fabric, which is made up of intertwined loops. Some knitwear used in clothing can be made up of a single, very long thread, so to speak.

For this reason, the strength of a knitted fabric is measured by specific methods, such as bursting strength.

BURSTING STRENGTH

Tear or tensile strength tests are not suitable for knitted fabrics. If necessary, burst strength is measured.

The test replicates the force exerted at the elbow or knee, for example. To do this, a sample of the knitted fabric is placed on a rigid frame above a flexible membrane, the diaphragm. Pressure is then applied under the diaphragm, which deforms and exerts pressure on the knitted fabric until it ruptures.

This test is also suitable for coated textiles and non-wovens.

ABRASION RESISTANCE

Abrasion of textile materials during use is an important wear factor.

To determine the wear resistance (abrasion) of a material, the textile to be tested is rubbed on a standardised, strong wool cloth with a certain force.

The number of cycles is counted until the material is worn out (e.g. broken threads). The number of frictions thus tells us how easily the material wears out. For some textile materials, the number of frictions is high (up to 30,000 or 50,000 revolutions) and for others it is low (10,000 revolutions).

ARTICLE	ROTATIONS	
	MINIMUM	EXTRA
TROUSERS AND SHORTS	20.000	40.000
SKIRTS	20.000	40.000
JACKETS	16.000	36.000
COATS	16.000	36.000
JERSEY	8.000 or more according to article	26.000
ANORAKS, SKI & SPORTS GARMENTS	16.000	26.000
PYJAMAS AND NIGHTWEAR	10.000	20.000
SHIRTS, DRESSES AND BLOUSES	12.000	22.000
LINGERIE	10.000	20.000
SWIM SUITS	20.000	30.000
LINING	10.000	20.000
WORK GARMENTS AND PROTECTIVE CLOTHING (PPE)	30.000 >50.000 if tested with a force of 9kPa	50.000

RESISTANCE OF CARPETS

To determine the wear and tear of a carpet, we apply a test method that simulates the wear and tear caused by a person walking on the carpet.

Think of a carpet that covers the steps of a staircase. You have probably already noticed that this carpet does not necessarily wear on the top of a step, but rather where the carpet wraps around the edge of the step. It is therefore best to take this into account.

As with other textile materials, there are several test methods for determining the wear of a carpet: the two most commonly used tests are the "Lisson" and the "Vetterman".

In the Lisson test, a metal foot simulates a person's foot stepping on a carpet strip.

This happens under certain conditions and causes the carpet to wear.

The carpet is placed in such a way that it wraps around a thick plate that imitates a stair step.

The foot therefore hits this board with every step, causing the carpet to wear.

The Vetterman test allows the producer to determine the end use of a carpet.

A carpet used in a shop has to be much more resistant to wear and tear than a carpet used in a bedroom.

That is why the industry has defined use classes that are displayed on the pictograms accompanying the product.

The pictograms also indicate whether a carpet can be used as a stair carpet or whether it is resistant to the wear of rolling wheelchairs.

COLOURFASTNESS

During use, textiles are usually exposed to external factors such as light, washing, ironing, sweat, friction and chemical agents.

The ability of a dyed or printed textile to retain its original appearance without fading when wet, washed or exposed to light also determines its life span.

This ability of dyed or printed textiles to retain their original colour is called "colour fastness".

Colour fastness depends on several factors:

- The type of fibre. The dye used and the fibre must be compatible. A cellulose fibre and a vat dye have good fastness. Polyesters work very well with disperse dyes.
- The molecular structure of the dyes: larger molecules will be well "trapped" within the polymer chain of the fibre and will therefore result in better strength.
- The way the dye is bound to the fibre
- The shade: for the same category of dyes, one shade may be more sensitive than others to light or washing.
- The presence of other chemical elements

COLOUR FASTNESS TO RUBBING refers to the degree to which dyed fabrics will fade after rubbing. This may be due to dry rubbing or wet rubbing. Rub fastness is determined from the degree of discolouration of a standard white cloth that is rubbed on the textile to be tested, and is classified into 5 levels.

The higher the value, the better the rub fastness.

COLOUR FASTNESS TO LIGHT refers to the degree to which coloured fabrics fade when exposed to sunlight. The colour fastness to light test is carried out by comparing the degree of fading of the sample after simulated sunlight with a standard colour sample divided into eight grades. 8 represents the highest light fastness, 1 the worst.

Ideally, for fabrics to remain in optimum condition, they should not be exposed to sunlight for long periods, and they should also always be dried in the shade in a ventilated area.

COLOUR FASTNESS TO WASHING refers to the degree of colour change in the dyed or printed fabric after washing with a liquid detergent. Usually, a grey-scale sample card is used as the standard for evaluation; the difference in colour between the original sample and the faded sample is compared to the differences between shades of grey.

Wash fastness is graded in five levels; grade 5 is the best while grade 1 is the worst.

DIMENSIONAL STABILITY

In everyday life, new clothes, sheets and other textiles that shrink excessively after one or two washes in water, affect the consumer experience.

Upholstery or carpets are usually not washed (except for a bath mat) but cleaned.

We all know that textiles shrink when they are washed for the first time. This can be very annoying and can be a reason why textile products quickly end up in the bin.

The level of shrinkage of a textile material can easily be determined in the laboratory.

After applying marking lines to a piece of fabric at a certain distance from each other, the fabric is washed under defined conditions and the distance between marks is measured again after drying. This distance is then compared to the distance of the markings before washing. The difference is expressed as a percentage (%).

Of course, a textile should shrink as little as possible, but in many cases, this cannot be avoided. A textile material with a shrinkage of less than 3% after 5 washes is a good textile material and is suitable for clothing.

For knitwear, however, stretching (negative shrinkage) or more pronounced shrinkage is possible after washing. A margin of 5% is acceptable.

APPEARANCE AFTER WASHING

Some textile products (garments, household linen) are frequently washed. Washing alters the appearance of textiles (fading colours, creasing, matting, etc.).

The appearance of textiles after washing includes the evaluation of colour change, pilling, fuzzing, matting appearance of fabrics, smoothness appearance of flat fabric and seams, and the retention of pressed-in creases in garments and other textile products, damage of components – buttons, press fasteners, slide fasteners, etc.

Garments or other textile end products are subjected to procedures simulating domestic laundering practices.

Garments or other textile end products are visually assessed under specified illumination.

A supplemental spotlight suitably placed to highlight the creased area of the textile is used in crease evaluation.

If required, garments or other textile end products are compared visually with plastic smoothness appearance replicas, plastic crease replicas and/or photographic seam standards under specified illumination.

ECO-IMPACT

LIFE CYCLE ASSESSMENT (LCA)

Eco-design targets a reduction of the environmental impact of the activities necessary to deliver products and services. This implies that it must be possible to quantify the impact, and in turn, to compare different products, development options, etc.

Life cycle assessment (LCA) is a scientific tool for quantifying the environmental impacts associated with a product or service, following the ISO 14040 and 14044 guidelines.

LCA always starts at the origin (cradle) of the studied system. The boundary can be drawn at different life stages, for example the production phase (factory gate), use phase or end-of-life phase (grave). The aim is to quantify all the natural resources extracted and all the emissions released, starting from the cradle.

Consider the example of cotton fibres. The first idea might be that it is a natural fibre, and therefore with a reduced environmental impact. But depending on how cotton is grown, the negative impact on the environment can be considerable, due to the quantity of water required for irrigation, the use of harmful phytosanitary products that can have harmful effects on human health and on ecosystems. LCA's covering conventional cotton and organic cotton would enable a proper comparison.

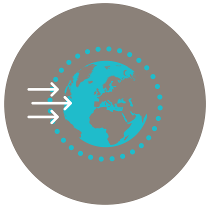
When all the emissions and resources related to the studied product or service (in the example cotton fibres) are collected in an inventory, the so-called life cycle inventory, they can be translated into environmental impacts by multiplying them with specific characterization or conversion factors. Different impact assessment methodologies exist to calculate all these environmental impacts, each using different sets of characterization factors, meaning that the final result can also be different. Therefore, it is important to only compare results obtained with the same method.

A complete LCA covers several categories of environmental impacts. Global Warming or Climate Change is probably the best-known category. Carbon dioxide and other greenhouse gases accumulate in the atmosphere, trapping solar heat which increases the earth's average temperature.

Besides Global Warming, there are many other environmental impact categories. The main ones are visually presented below: acidification, ozone depletion, ozone formation, eutrophication, ecotoxicity, human toxicity, ionizing radiation, particulate matter, water use, land use and resource depletion.

Other categories and/or subcategories also exist, depending on the impact methodology.

CLIMATE CHANGE

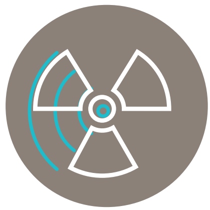


OZONE DEPLETION

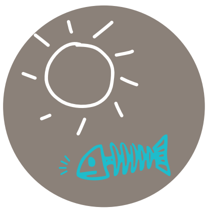
ACIDIFICATION

WATER USE

PARTICULATE MATTER



IONIZING RADIATION



EUTROPHICATION

OZONE FORMATION

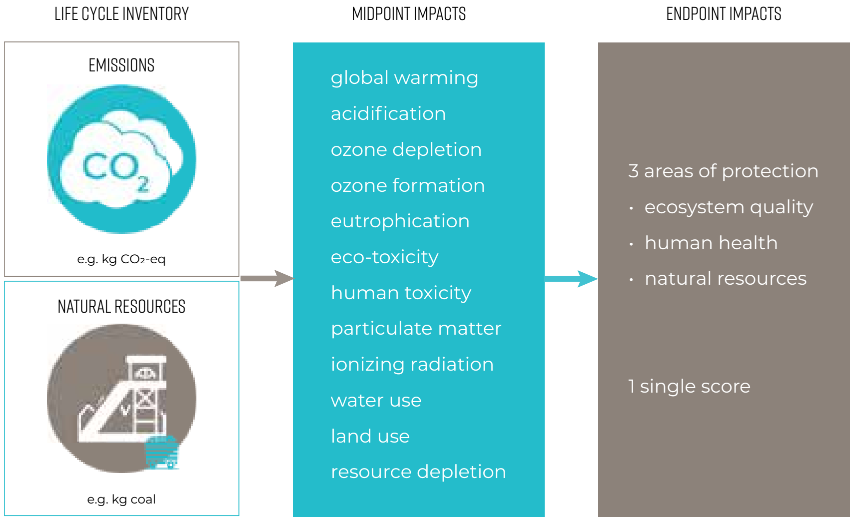
DEPLETION OF NATURAL RESOURCES

ECO-TOXICITY

HUMAN TOXICITY

LAND USE

In a further step, these impacts can be aggregated into three areas of protection (Human Health, Ecosystem Quality and Resources) or even in one single impact score.



Different steps in an LCA, from natural resources to single score impact

When all emissions and resources are collected in the so-called life cycle inventory, they can be translated into environmental impacts by multiplying them with specific characterization or conversion factors.

Such an assessment requires reliable data. All the emissions and natural resources associated with the supply chain of your product are typically modelled through databases.

The best-known database to calculate environmental impacts is probably Ecoinvent, widely regarded as the largest, most consistent and most transparent database on the market.

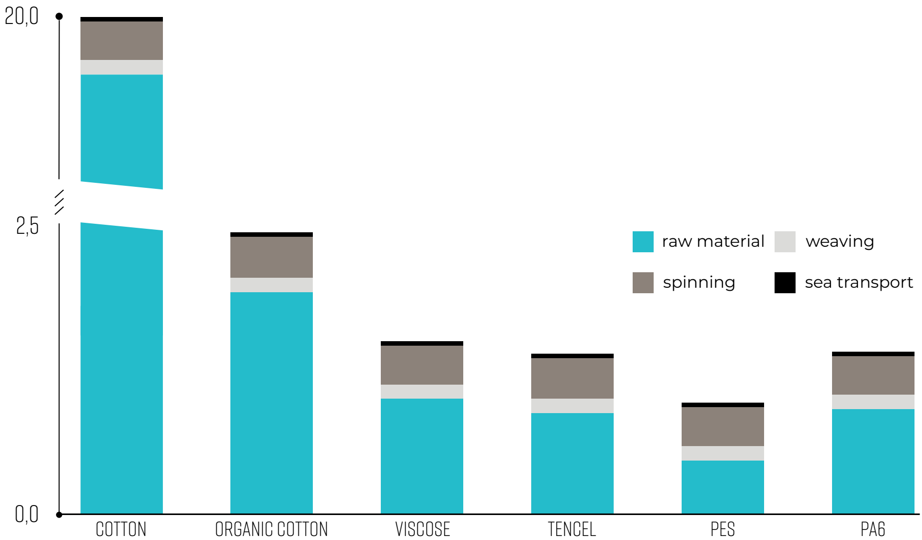
This database is coupled with software tools (e.g. SimaPro, OpenLCA) to perform all the complex calculations to generate environmental impact results.

PROS

- Provides a precise measure of the environmental impact of a product/ process
- Enables comparisons
- Helps defining priorities
- Several impact categories considered
- Existing norms
- Simplified tools available (bAwear)

CONS

- Complex
- Requires an LCA expert
- Expensive



Visualisation of the eco-impact of different fibres

By way of example, this above graph compares the environmental impact of different fibres used to make a fabric.

Four stages of production have been isolated for comparison: raw materials (fibre production or cultivation), spinning, weaving, shipping (Asia-Europe).

Logically, this study confirms that the biggest impact comes from the type of fibre and the way it is produced. This is particularly notable for organic cotton, which scores much more favourably than conventional cotton. This is due in particular to factors linked to the toxicity of the pesticides and other chemical substances used in cultivation.

Another notable point is the low relative impact of maritime transport.

PRODUCT ENVIRONMENTAL FOOTPRINT (PEF)

Initiated by the European Commission, the Product Environmental Footprint (PEF) is a rigorous method for measuring the environmental impact of a product or service.

One of the main objectives of this approach is to limit the possibilities of greenwashing and the multiplication of labels by offering a common tool to all EU member states. It should also allow a reliable comparison between products and services and thus foster the development of the circular economy.

Based on a multi-criteria approach, and in particular on life cycle assessment (LCA), it allows the environmental impact of a good or service to be quantified and displayed.

A total of 16 LCA impact categories are taken into consideration, such as climate change, fine particles, and human toxicity. In addition, product categories will be defined to make the results even more accurate and comparable.

The development phase could last until the end of 2024. It involves many stakeholders, including scientists, organisations, and private companies.

CERTIFICATION

Certification is a procedure whereby an external assessment body (audit office, certification body, authorities, etc.) verifies that a product, process, service or person complies with the requirements set out in a reference system (standard, directive, specifications, etc.) and formalises this in written form.

ISO (International Organisation for Standardisation) defines certification as the written assurance (in the form of a certificate) given by a third party that a given product, service or system is in conformity with specific requirements.

As a general rule, when certification refers to a series of parameters or rules to be complied with, a certified body is required to verify compliance with these rules or standards.

On the other hand, a certification process is not necessarily the responsibility of an official body or any other authority. It can also be part of a commercial framework, particularly when labels are used.

Depending on the type of certification, the assessment process takes place within the company, or through tests carried out by an accredited laboratory.

Documents and certificates will mostly contain:

- **NAME OF THE CERTIFIED BODY**: the applicant
- **CERTIFYING BODY**: the body carrying out the assessment
- **NORM, STANDARDS, REFERENCE SPECIFICATIONS:** a single reference system
- **FIELD OF APPLICATION, SPECIFIC CERTIFIED PRODUCTS:** the specific field covered
- **DATE OF ISSUE OF CERTIFICATION, REPORT REFERENCE:** identification of the report(s)
- **PERIOD OF VALIDITY** varies according to the type of certification

Certifications are frequently used in the textile industry. Here are a few examples:

- **ISO 9001:** ISO standard for quality management
- **GOTS**: label for certified organic cotton
- **CE MARKING:** products that comply with a series of EU requirements in terms of health, safety, etc.
- **OEKO-TEX® STANDARD 100:** textiles tested for harmful substances

LEGEND

eco-friendly

eco-design

points of attention

recycling

not eco-friendly

labels

source

characteristics

markets/applications

positive

negative

all paper and/or other wood-based materials used to produce this guide come from 100% recycled material.