This project is co-funded by the European Union
and the Republic of Türkiye

BUTEXCOMP

“Composite Material and Technical Textile Prototype Production and Application Center“ Technical Assistance Project

Seminar on Sustainable Design of Textiles and Recycling of Textile

26.03.2024

REPUBLIC OF TÜRKİYE
MINISTRY OF INDUSTRY
AND TECHNOLOGY

BTSO
BURSA CHAMBER OF COMMERCE AND INDUSTRY

BUTEKOM
Bursa Technology Coordination and R&D Center

COMPETITIVE SECTORS PROGRAMME

Manisha Marival
CETI (European centre for innovation in textiles), France

Johannes Leis
Saxon Textile Research Institute, Chemnitz, Germany

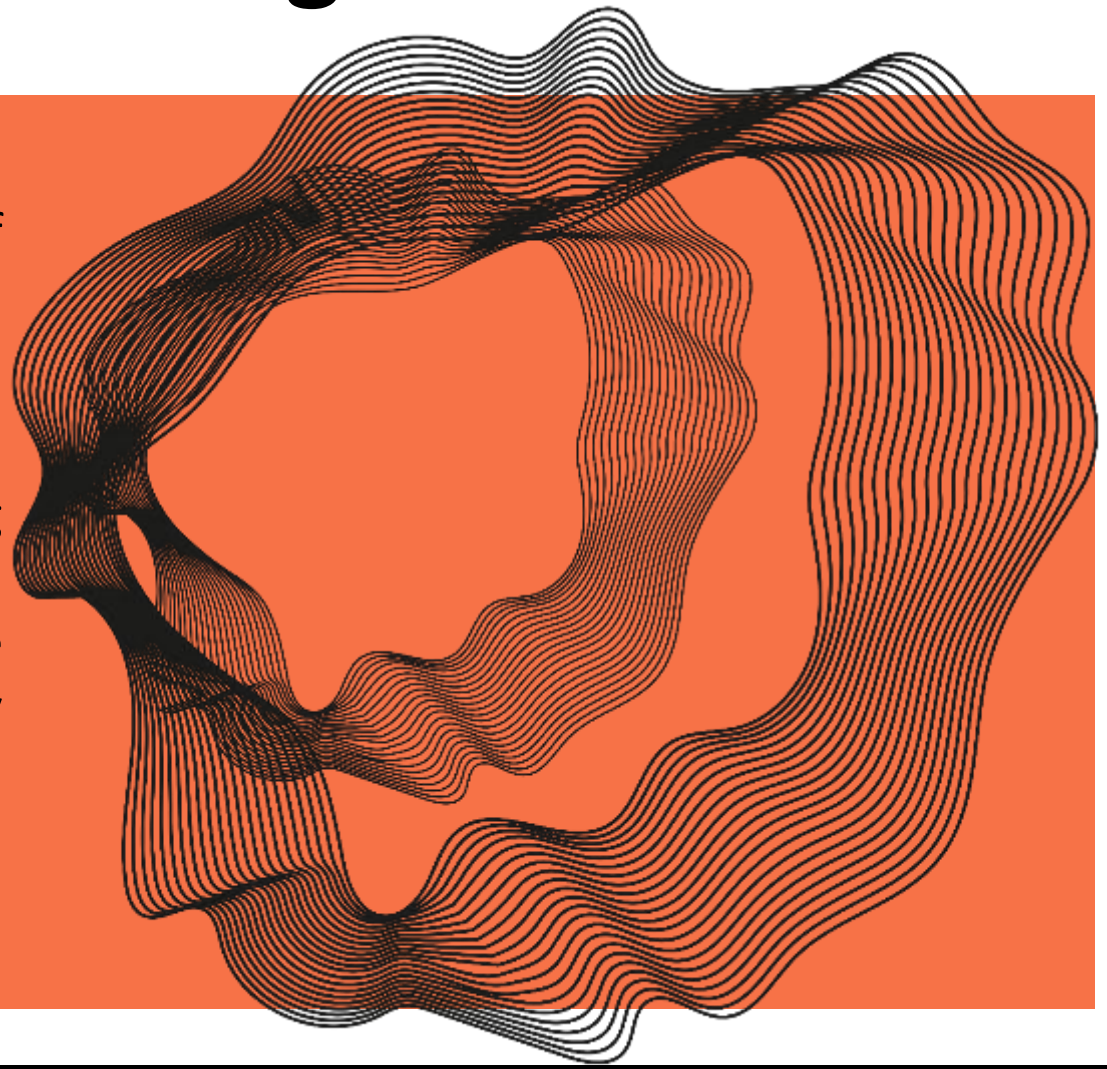
Ceti TRANSFORMATIVE TEXTILES

stfi

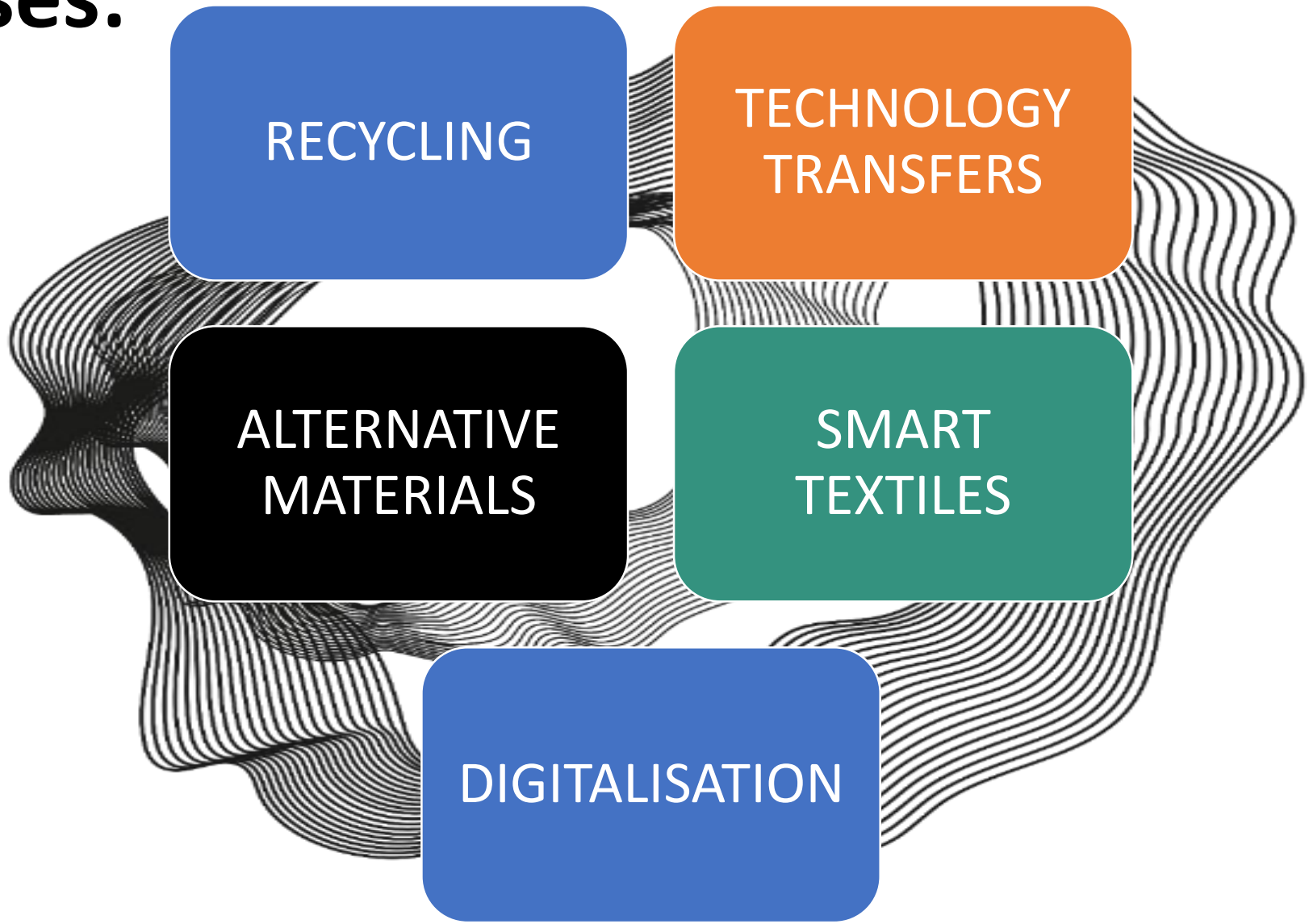
CETI : A creative and technological leader

CETI is a private R&D center based in the north of France and is dedicated to the **Experimentation** and **Industrialization** of textile materials.

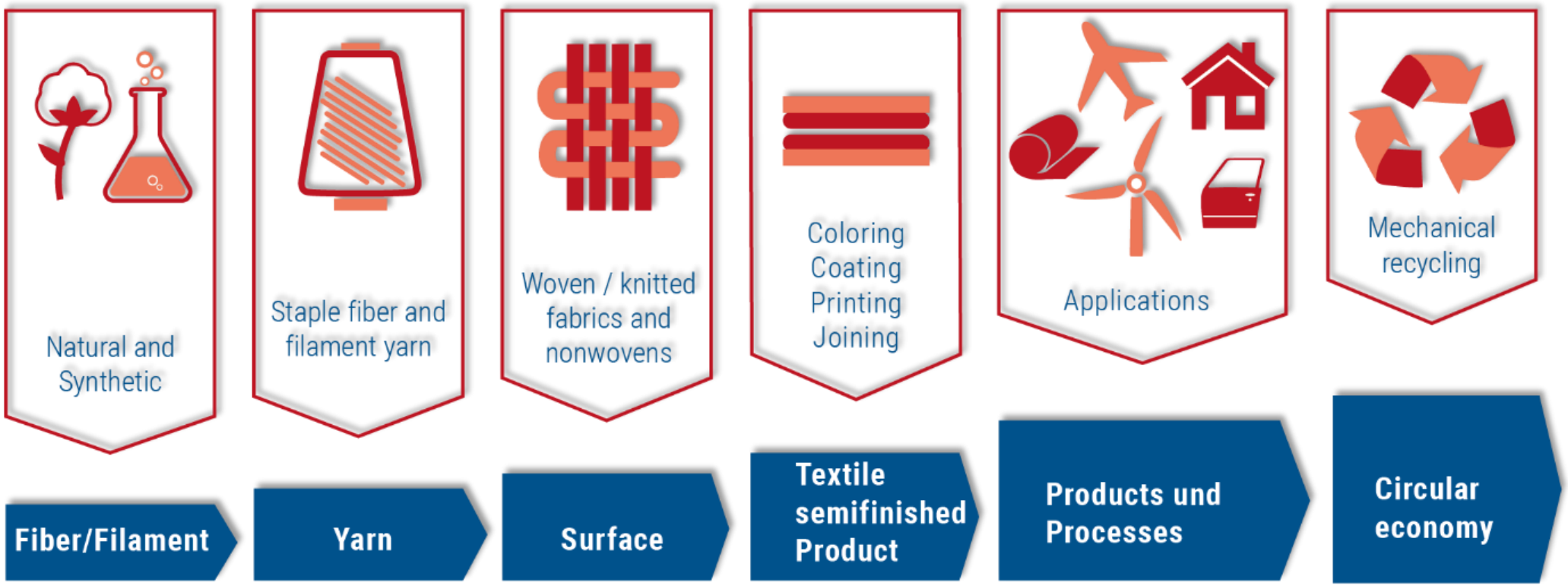
This unique collaborative place of creativity, engineering and prototyping has been innovating for 12 years for the big names fashion, sports, luxury, and technical textiles. We have the knowledge base and machine setup to accompany clients from TRL1 to TRL9



Our expertises:



We cover the entire textile chain



Program

Program	
State of the textile industry	14:00 - 14:20
Circular economy and why do we need it?	14:20 - 14:45
Regulations	14:45 - 15:00
Circular Design	15:00 - 15:30
Sorting of textile waste	15:30 - 16:00
Recycling technologies for textile waste	16:00 - 16:30
Textile fiber market of the future	16:30 – 17:00

Ceti TRANSFORMATIVE TEXTILES

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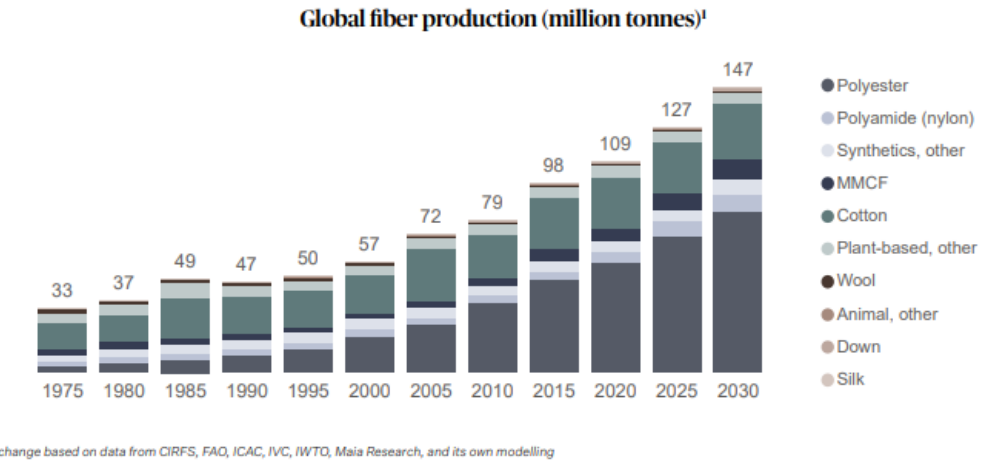
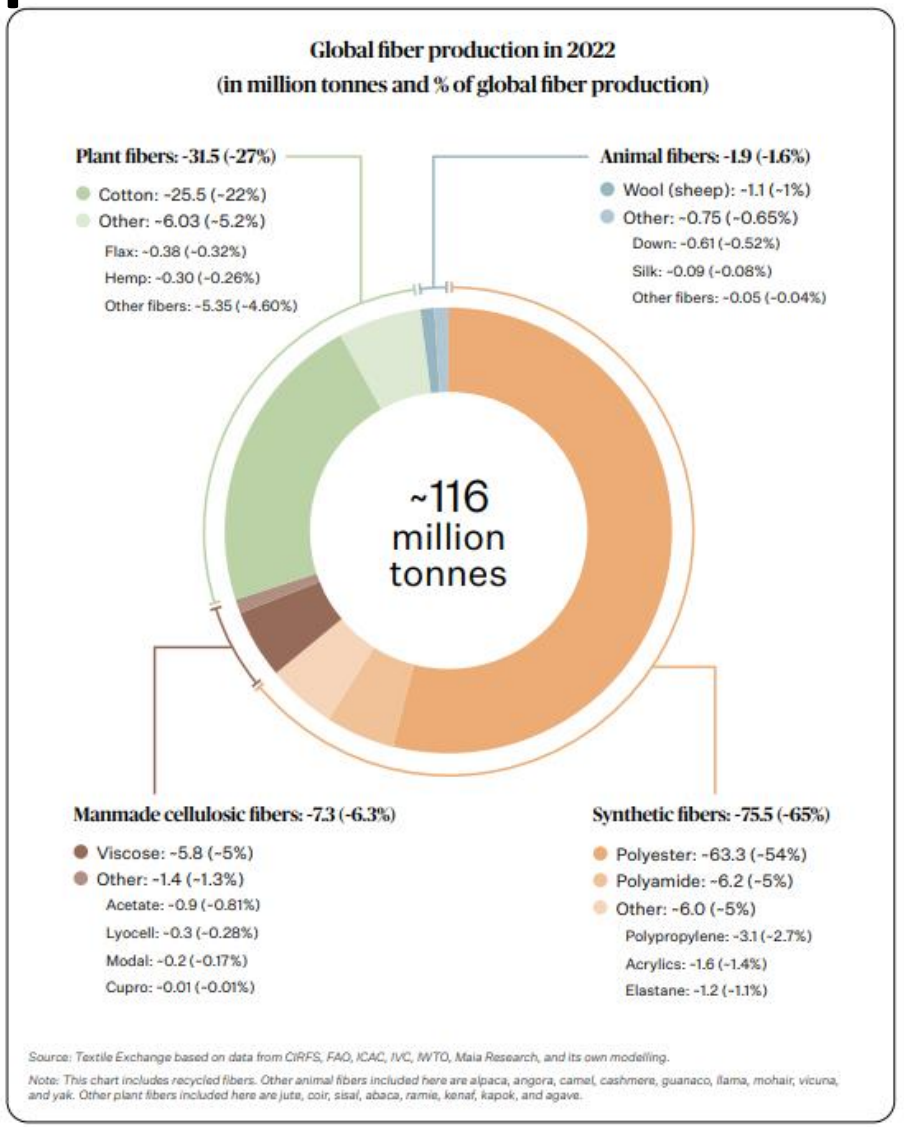
The state of the textile industry

Evolution of the global fiber production



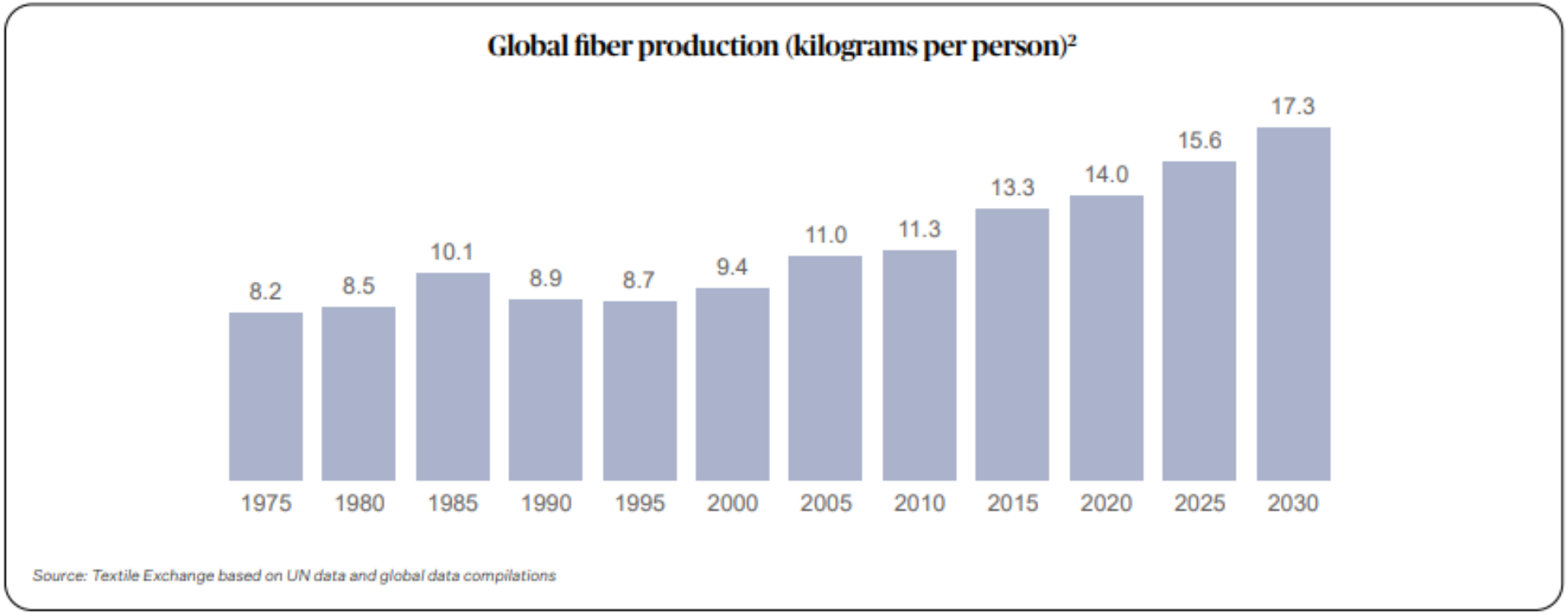
Source: Textile Exchange based on data from CIRFS, FAO, ICAC, IVC, IWTO, Maia Research, and its own modelling



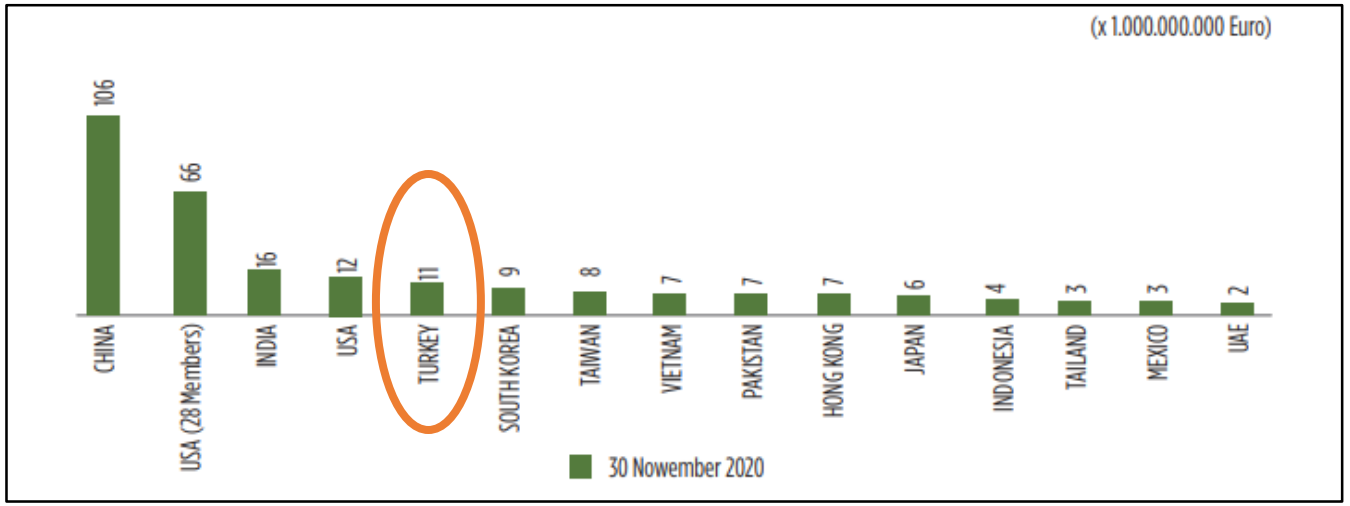
Source: Textile Exchange based on data from CIRFS, FAO, ICAC, IVC, IWTO, Maia Research, and its own modelling.

Note: This chart includes recycled fibers. Other animal fibers included here are alpaca, angora, camel, cashmere, guanaco, llama, mohair, vicuna, and yak. Other plant fibers included here are jute, coir, sisal, abaca, ramie, kenaf, kapok, and agave.

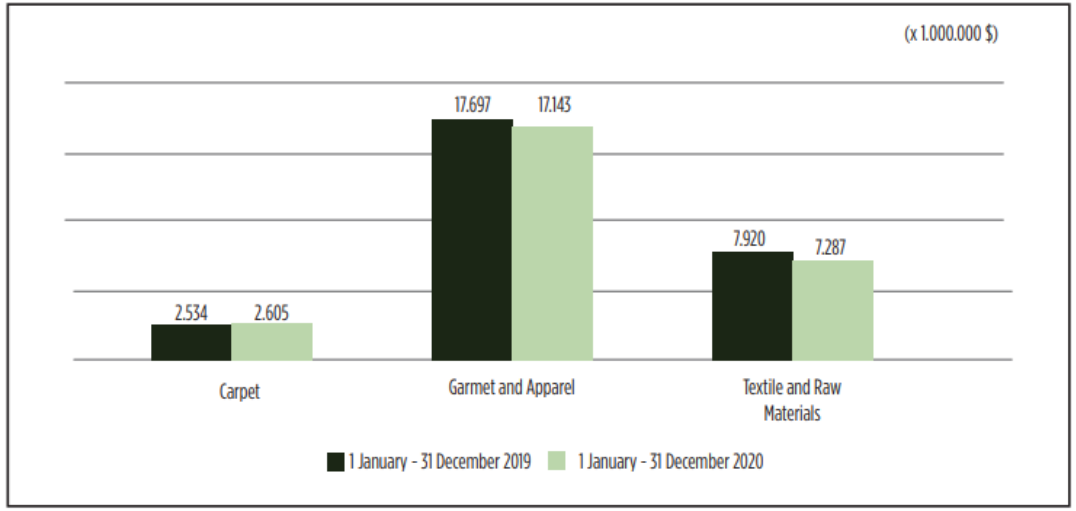
Evolution of the global fiber production



Turkish scenario



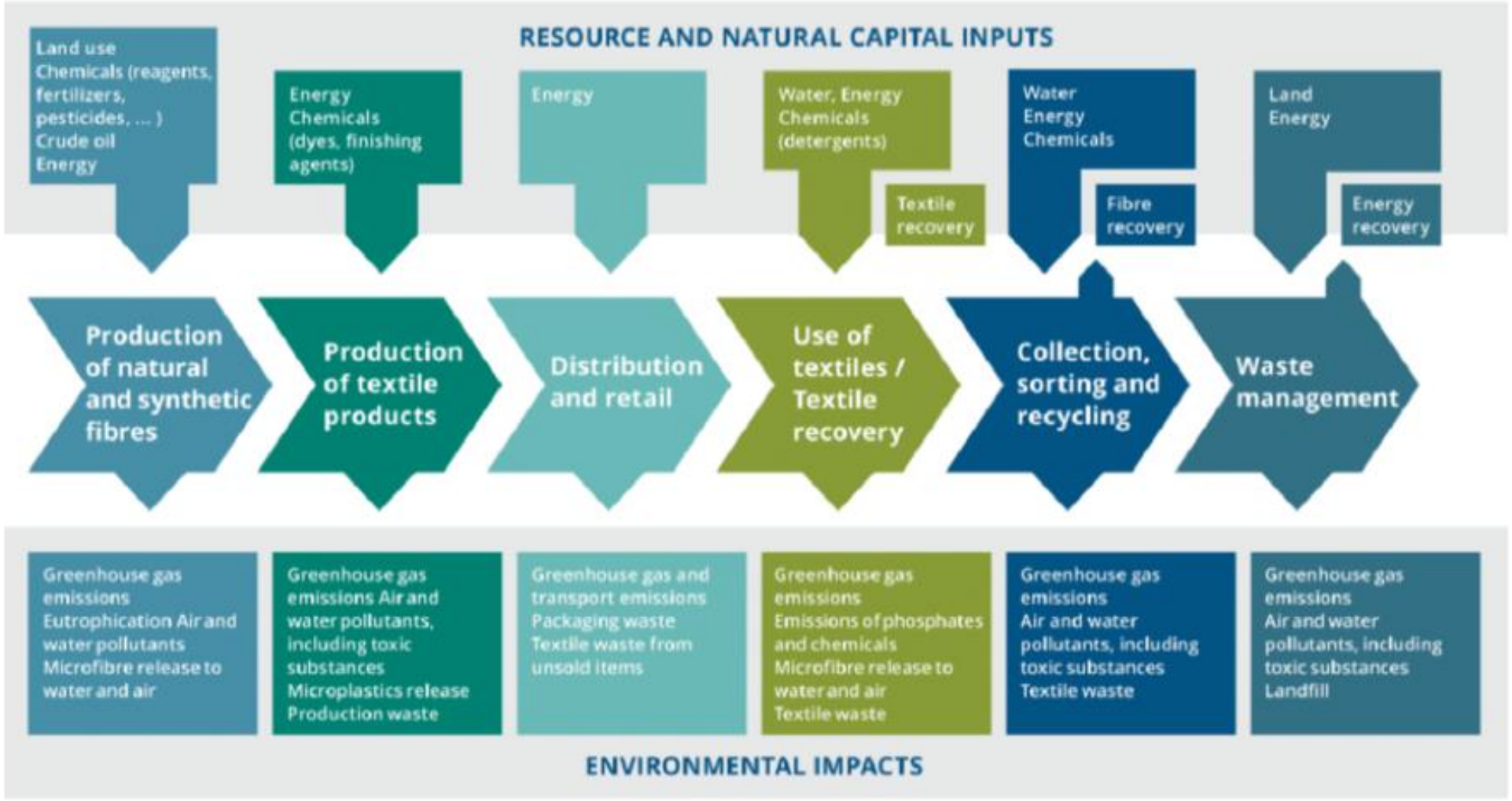
Top 15 Textile Exporting Countries

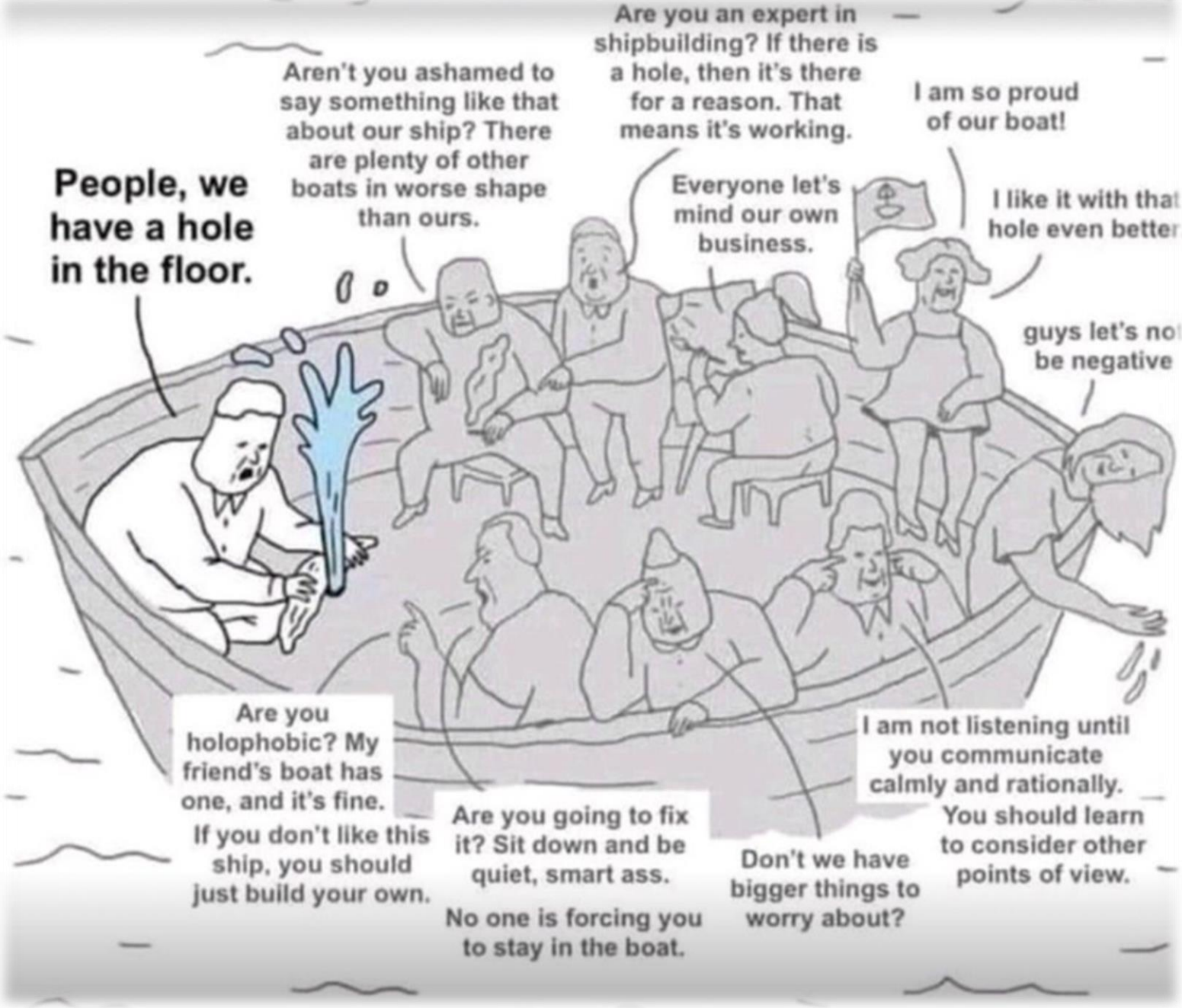


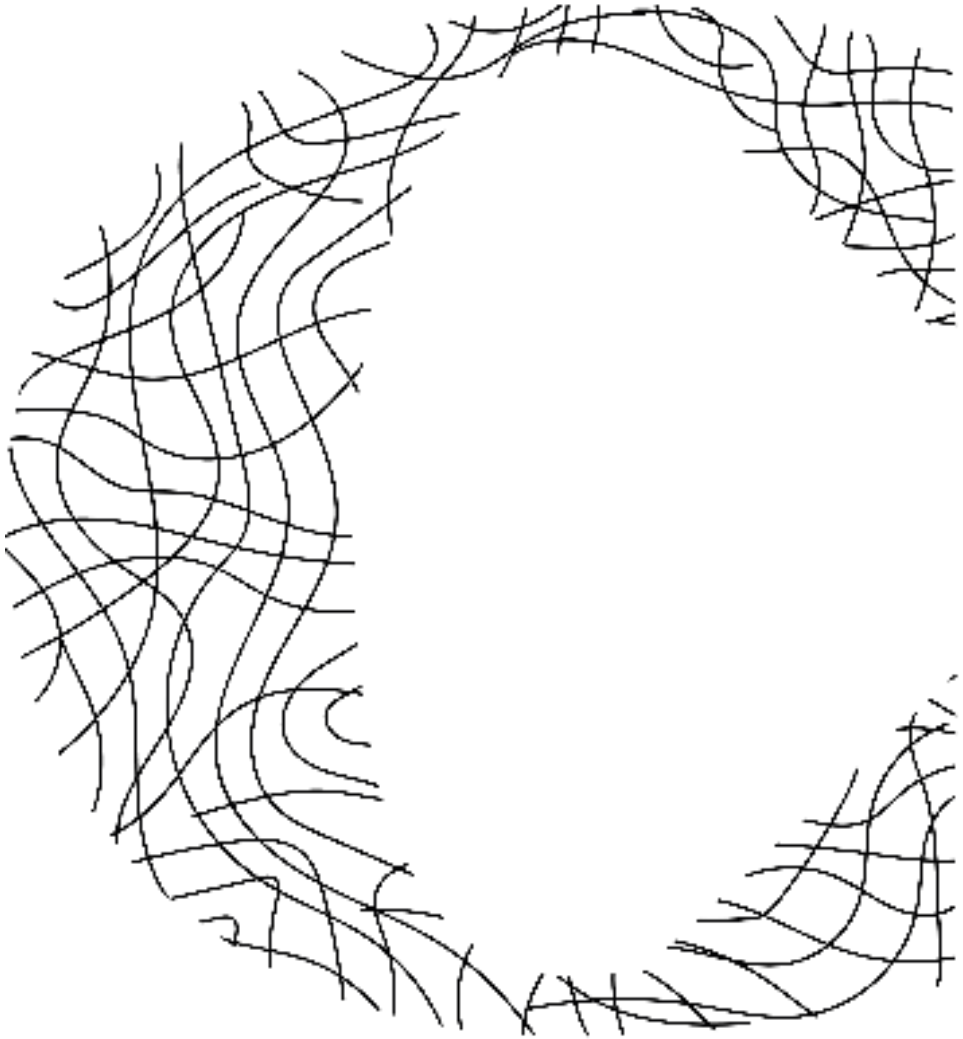
Turkey's Carpet, Garment, Apparel, Textiles and Raw Materials Exports ($)

Source: https://www.undp.org/sites/g/files/zskgke326/files/migration/tr/tekstil-trc2_eng.pdf


Up to 100 BILLION
new garments are made each year
87%
Of materials used to make clothing
END UP IN LANDFILL
That's one truckload
EVERY SECOND
The World Produces
92 Million Tons
of textile waste every year
60%
of all new clothing materials are actually
PLASTIC
TheRoundup.org
Textile Production Causes
42 MILLION TONS
of plastic waste per year and contributes
9%
of annual microplastic pollution added to our oceans.
1%
Of clothes are
RECYCLED INTO NEW GARMENTS


RESOURCE AND NATURAL CAPITAL INPUTS
Land use
Chemicals (reagents, fertilizers, pesticides, ...)
Crude oil
Energy
Energy
Chemicals (dyes, finishing agents)
Energy
Water, Energy
Chemicals (detergents)
Textile recovery
Water
Energy
Chemicals
Fibre recovery
Land
Energy
Energy recovery
Production of natural and synthetic fibres
Production of textile products
Distribution and retail
Use of textiles / Textile recovery
Collection, sorting and recycling
Waste management
Greenhouse gas emissions
Eutrophication Air and water pollutants
Microfibre release to water and air
Greenhouse gas emissions Air and water pollutants, including toxic substances
Microplastics release
Production waste
Greenhouse gas and transport emissions
Packaging waste
Textile waste from unsold items
Greenhouse gas emissions
Emissions of phosphates and chemicals
Microfibre release to water and air
Textile waste
Greenhouse gas emissions
Air and water pollutants, including toxic substances
Textile waste
Greenhouse gas emissions
Air and water pollutants, including toxic substances
Landfill
ENVIRONMENTAL IMPACTS


People, we have a hole in the floor.
Aren't you ashamed to say something like that about our ship? There are plenty of other boats in worse shape than ours.
Are you an expert in shipbuilding? If there is a hole, then it's there for a reason. That means it's working.
Everyone let's mind our own business.
I am so proud of our boat!
I like it with that hole even better
guys let's not be negative
Are you holophobic? My friend's boat has one, and it's fine.
If you don't like this ship, you should just build your own.
Are you going to fix it? Sit down and be quiet, smart ass.
No one is forcing you to stay in the boat.
Don't we have bigger things to worry about?
I am not listening until you communicate calmly and rationally.
You should learn to consider other points of view.



What is Eco Design & Why is it important?

What is Eco Design & Why is it important?

➢ **Definition of Ecodesign by EEA**

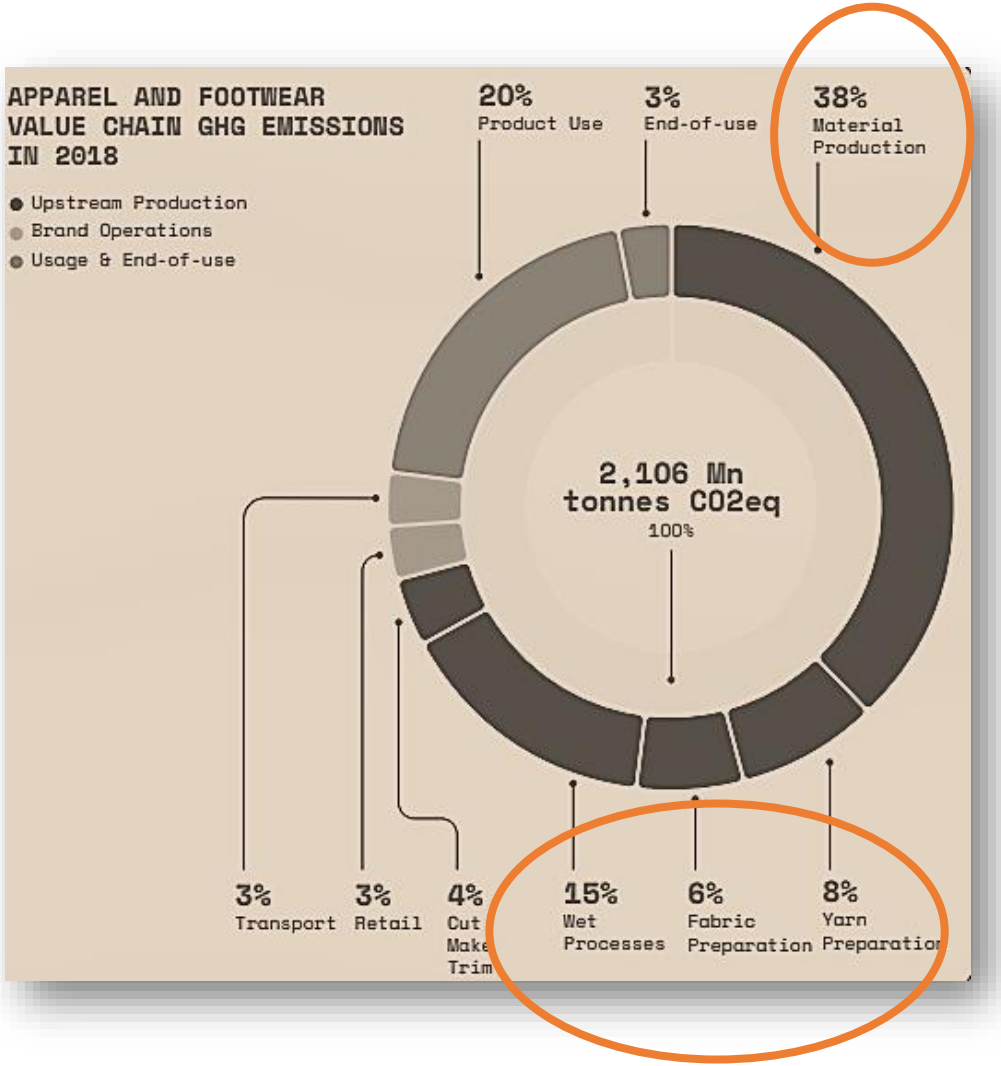
Eco design is the integration of environmental aspects into the product development process, by balancing ecological and economic requirements. Eco-design considers environmental aspects at all stages of the product development process, striving for products which make the lowest possible environmental impact throughout the product life cycle.

➢ **Why is it important:**

"...it is estimated that decisions made in design are responsible for eighty to ninety percent of a product's environmental and economic costs." (Graedel et. al., 1995)

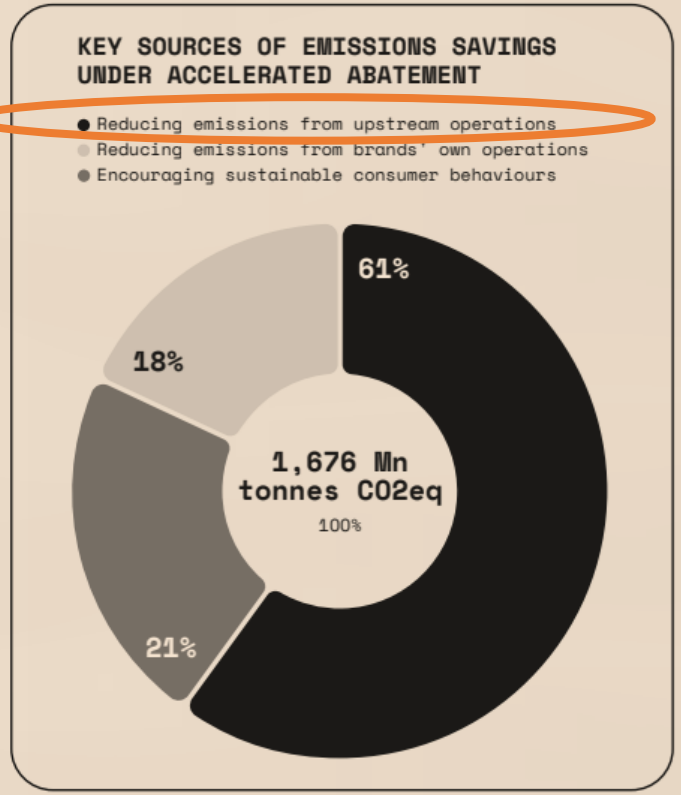
(*GRAEDEL, Thomas E., COMRIE, Paul Reaves, et SEKUTOWSKI, Janine C. Green product design. AT&T technical journal, 1995, vol. 74, no 6, p. 17-25.*)

Eco Design & Why is it important?



THE INDUSTRY'S ACCELERATED ABATEMENT POTENTIAL

"60% OF THE ACCELERATED ABATEMENT POTENTIAL LIES IN DECARBONISING UPSTREAM OPERATIONS, 20% LIES IN BRANDS' OWN OPERATIONS, AND 20% RELIES ON ENCOURAGING SUSTAINABLE CONSUMER BEHAVIOURS"



Eco Design & Why is it important?

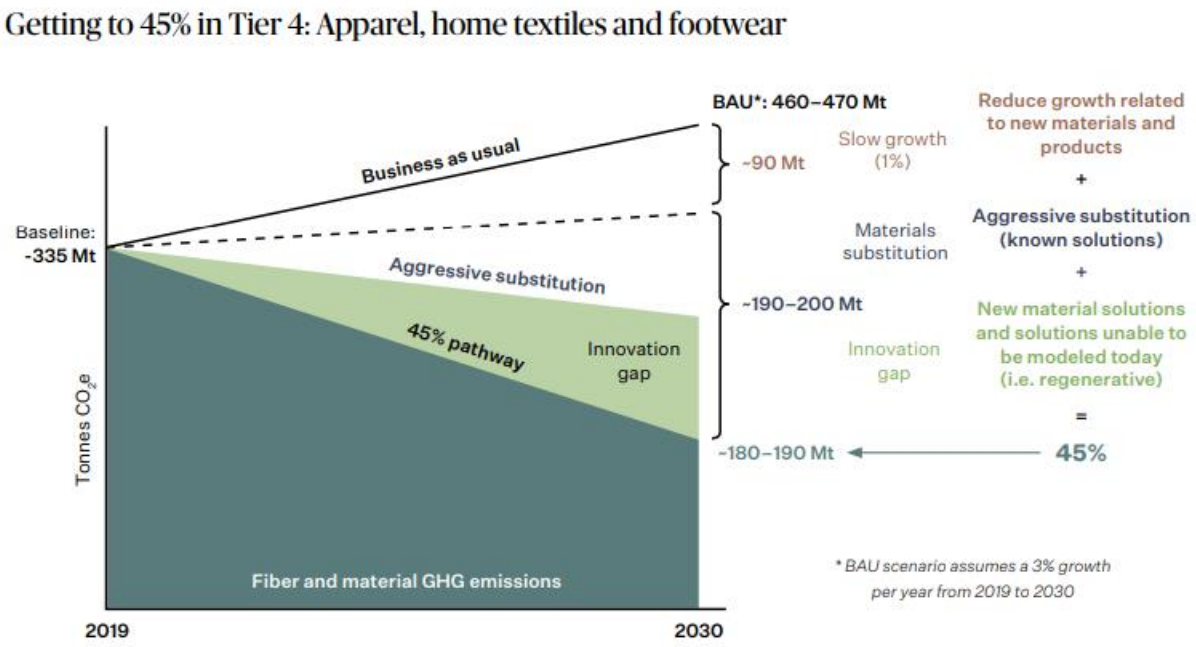
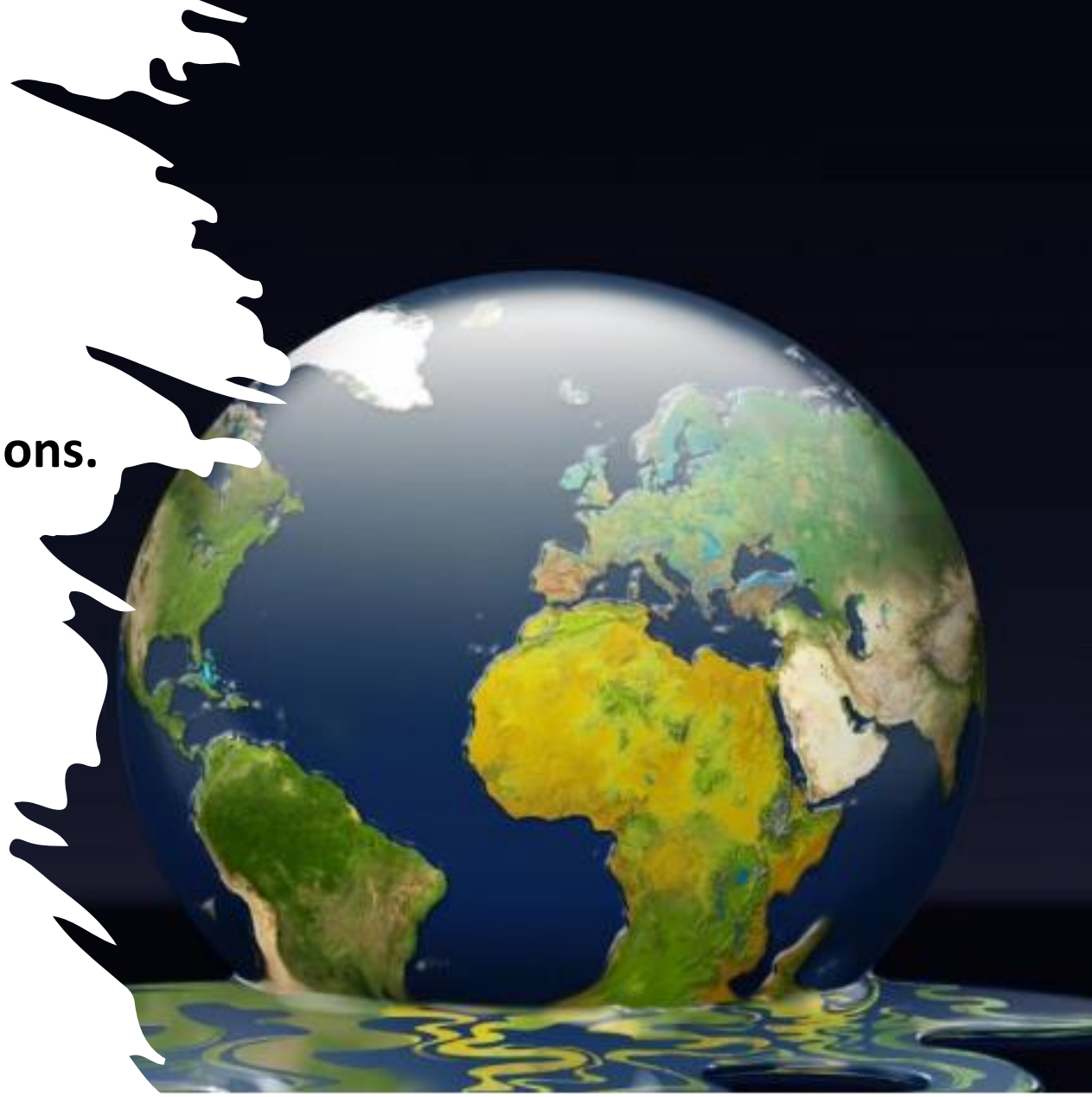


Figure 1: Modeling of interventions needed in the apparel and footwear raw materials extraction phase in order to achieve 45% GHG impact reduction by 2030, as measured against a 2019 baseline.

Why Ecodesign?

Climate Change:

It is estimated that the fashion industry is responsible for 10% of global carbon emissions.

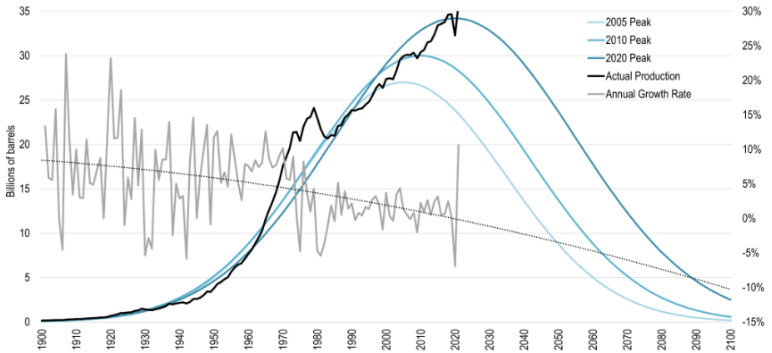


Why Ecodesign?

➢Resource Scarcity:

- **Cotton:** International cotton production is set to decline by 30-40% over the next 15 years. (Cotton 2040 report)

- **Synthetic:**



World Annual Oil Production 1900 2021 and Peak Oil 2005 2020 Scenarios

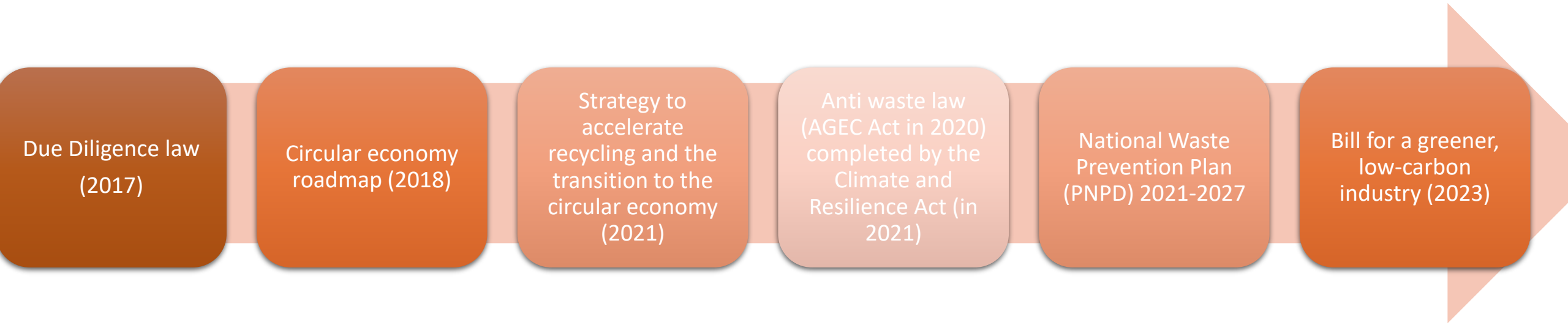
Source: Adapted from BP Statistical Review of World Energy.

- **Cellulosics:** Rising temperatures, forest fires and loss of biodiversity will all have a negative impact on production.

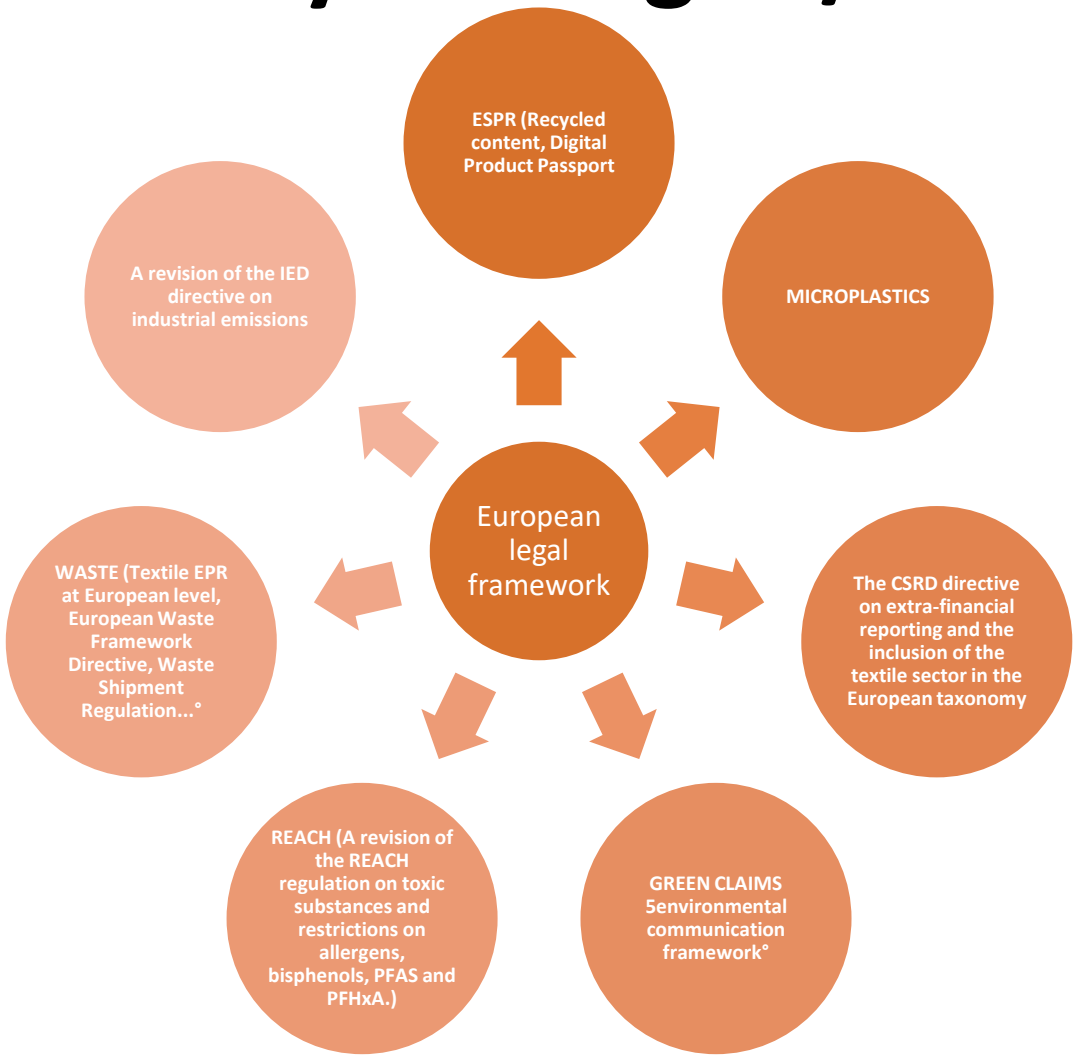
Why Ecodesign?

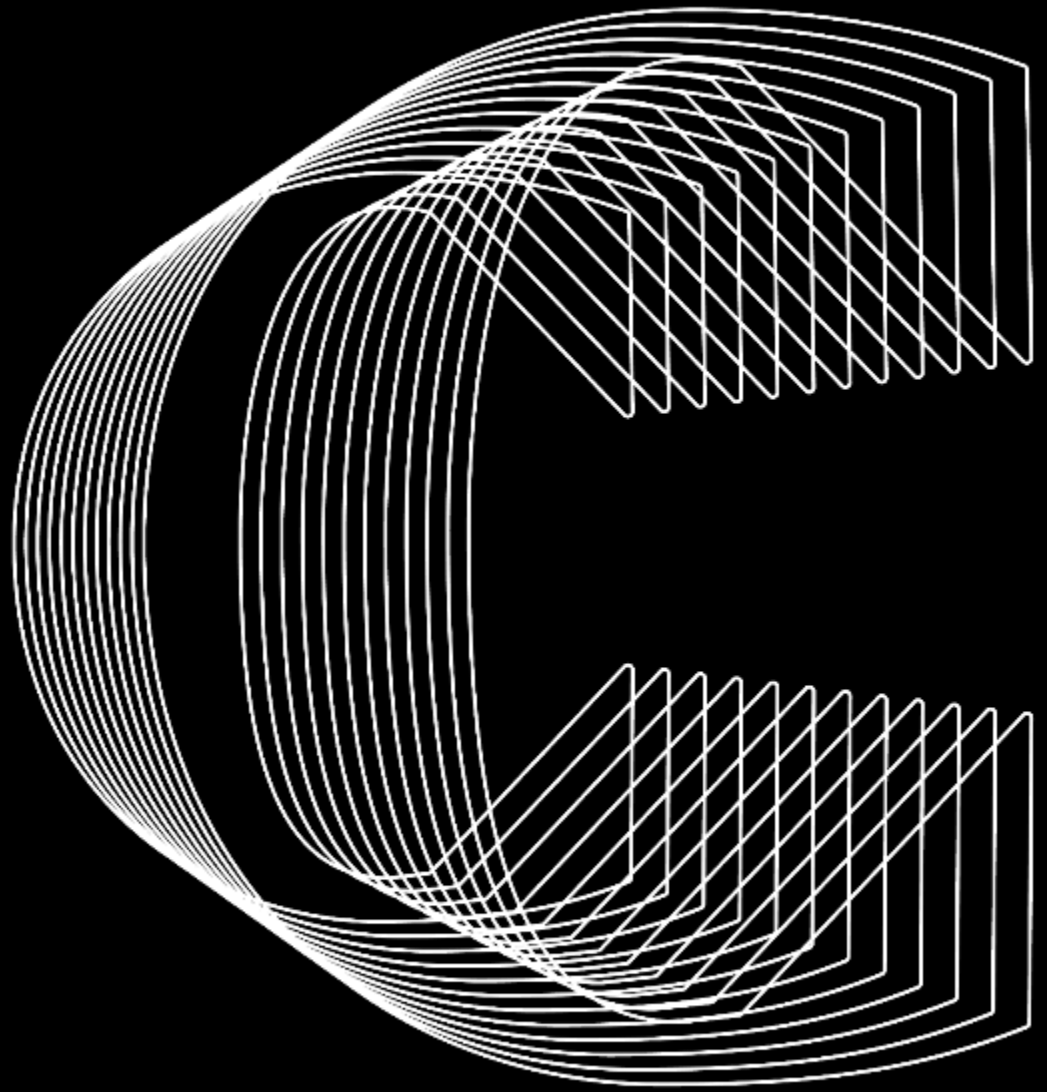
- Législation

Overview of French Sustainable and Circular Economy Strategies/Laws



Overview of European Sustainable and Circular Economy Strategies/Laws





The TED’s TEN

Ceti TRANSFORMATIVE TEXTILES

The TEN strategies by Earley & Politowicz

1
Design to Minimise Waste
V.2

2
Design for Cyclability
V.2

3
Design to Reduce Chemical Impacts
V.2

4
Design to Reduce Energy and Water Use
V.2

5
Design that Explores Cleaner/Better Technologies
V.2

6
Design that Takes Models from Nature & History
V.2

7
Design for Ethical Production
V.2

8
Design to Reduce the Need to Consume
V.2

9
Design to Dematerialise and Develop Systems & Services
V.2

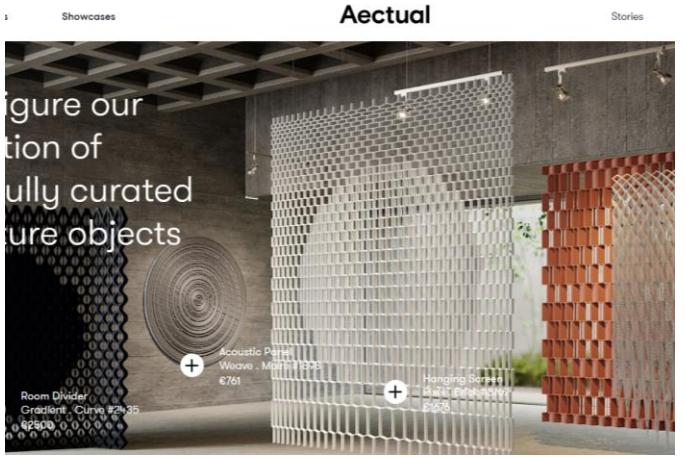
10
Design Activism
V.2

Gucci bids farewell to fashion week as brand goes seasonless

1

Design to Minimise Waste

V.2



2

Design for Cyclability

V.2

Are your clothes making you sick? The opaque world of chemicals in fashion

To Dye For
HOW TOXIC FASHION IS MAKING US SICK–AND HOW WE CAN FIGHT BACK
By ALDEN WICKERON TOUR

3

Design to Reduce Chemical Impacts

V.2

Ø ZDHC
Zero Discharge of Hazardous Chemicals

6

Design that Takes Models from Nature & History

V.2

La soie d'araignée Spiber séduit The North Face

7

Design for Ethical Production

V.2

PATAGONIA 3 IN ONE JACKET

8

Design to Reduce the Need to Consume

V.2

Balenciaga presents its Winter 2021 pre-collection, comprising 58 mainly unisex looks produced with 90% certified sustainable textiles. The digital lookbook features models in front of iconic tourist attractions that were added in post-production, anticipating a return to the possibility of global travel.

9

Design to Dematerialise and Develop Systems & Services

v.2

A l'opposé de la fast-fashion, les choix radicaux d'une créatrice anglaise pour la planète

Pour la collection qu'elle présente vendredi à la Fashion Week de Londres, Phoebe English n'a pas acheté un centimètre de tissu ou utilisé un seul bouton en plastique: elle a travaillé avec une obsession, ne pas nuire davantage à la planète.

Collection automne-hiver 2023/24 de Phoebe English (copyright). Site internet de Phoebe English

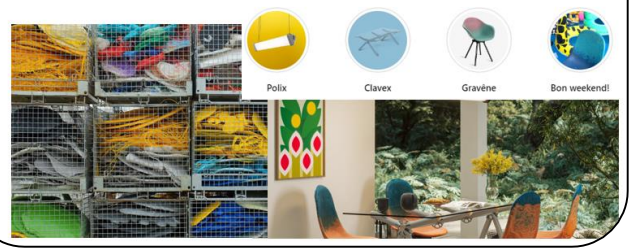
La mode est l'un des secteurs les plus polluants. Selon des estimations de la Banque mondiale, elle est responsable de jusqu'à 10% des émissions de gaz à effet de serre. Avec la fast-fashion, on achète pour quelques euros et on jette: des déchets qui se retrouvent souvent dans des décharges sauvages dans les pays du Sud.

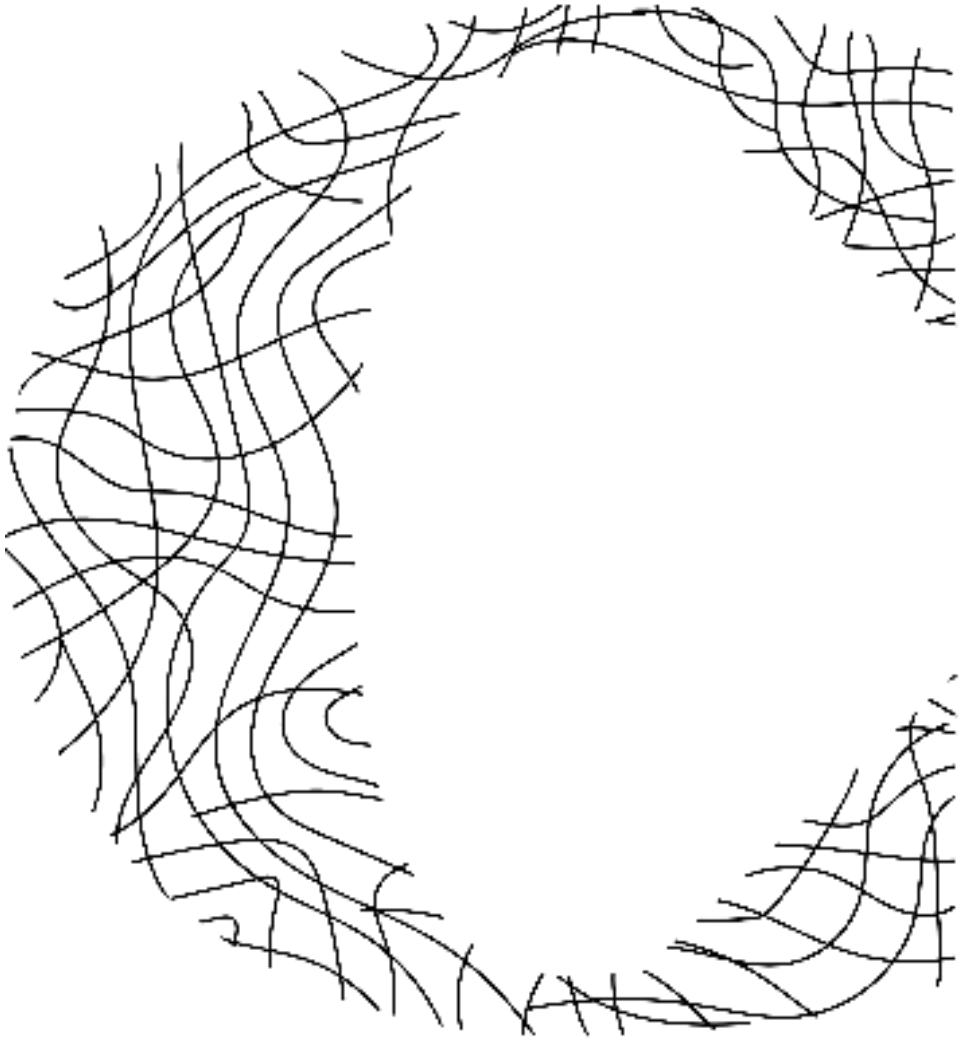
Phoebe English, âgée de 37 ans, a bien tout cela en tête. "On produit trop et trop vite. d'une manière tout à fait inutile. On doit vraiment y réfléchir: est-ce qu'on peut continuer comme ça, connaissant les limites de la planète?".

10
Design Activism

V.2

Bienvenue chez Maximum
Nous fabriquons du mobilier avec des excédents de production industrielle.

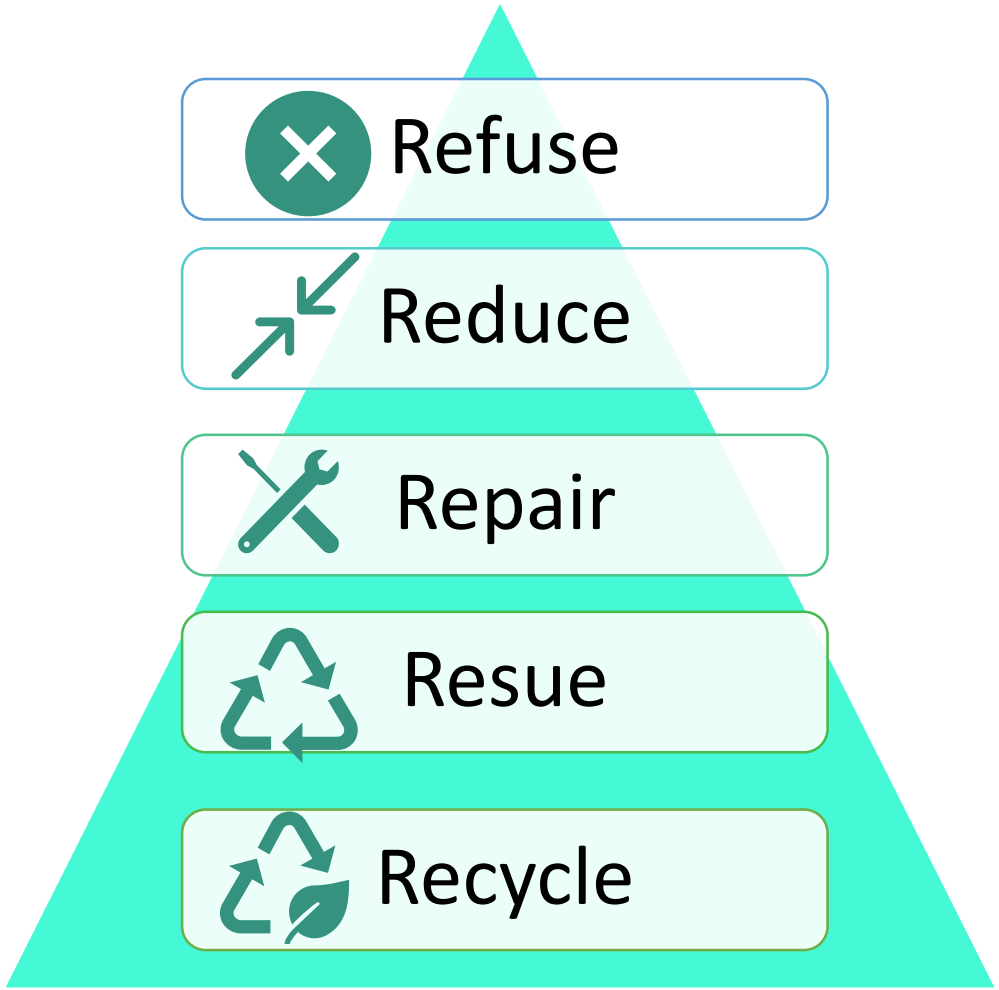




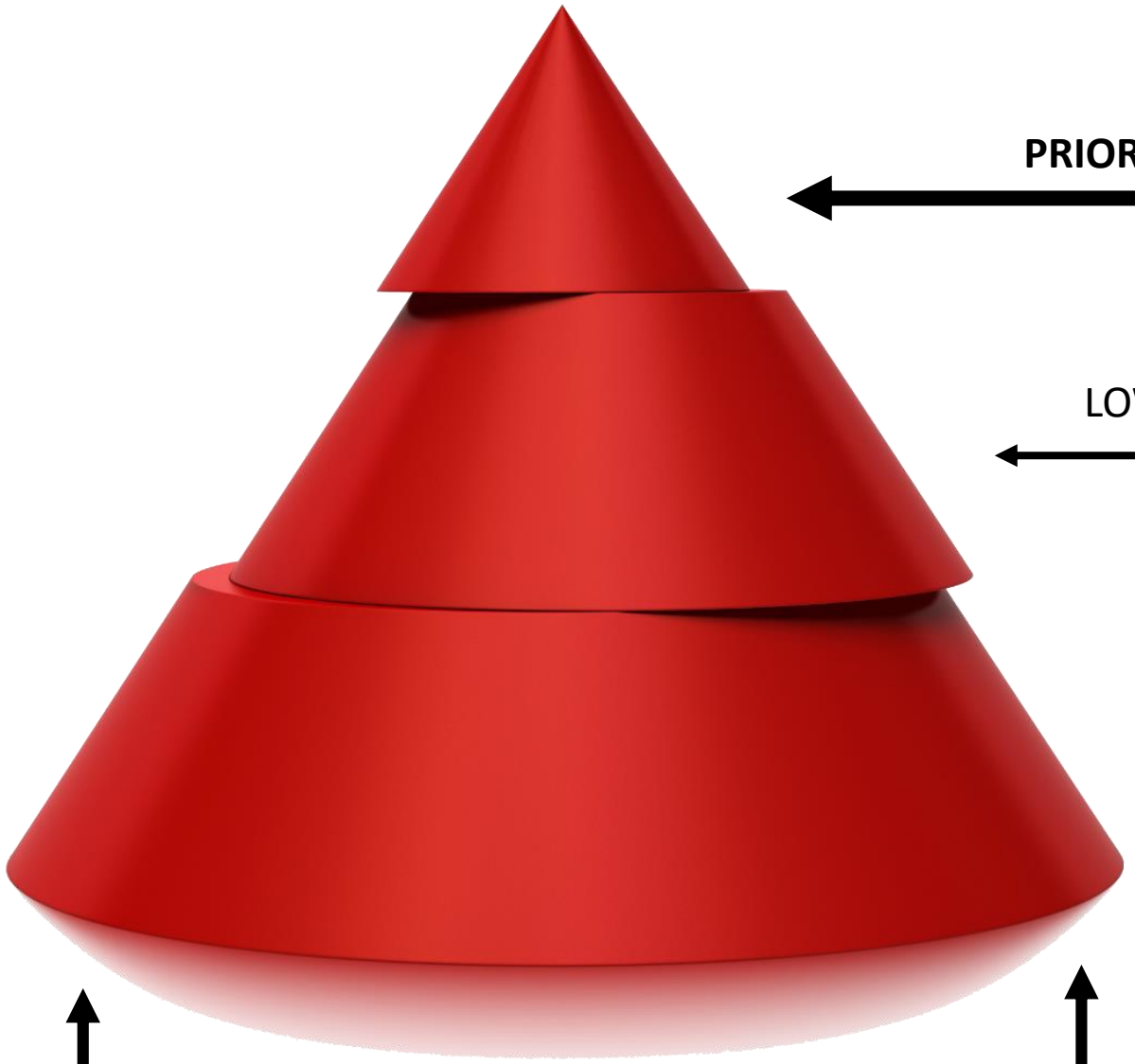
Tool Box

Ceti TRANSFORMATIVE TEXTILES

Recommended Hierarchy



	SLOWING DOWN THE LOOP			CLOSING THE LOOP
Circular Business Model	Longevity and durability	Optimised product use	Collection and reuse	Recycling and material reuse
Product Design	Quality/functionality			Easy disassembly
	Material choice			
	Safe chemicals and additives use			
	Repairability			Recyclability
	Availability of spare parts/repair services			
Consumer Behaviour	Emotional durability	Affordability/access	Correct disposal/collection/take-back systems	
	Customisation		C2C platforms	
	Care information and maintenance			
	Knowledge and awareness			
	Product labels			
	Traceability/product passport			
Policy	(Eco-design) standards			
	Taxes and fees			
	Ecodesign Directive	Regulation of waste ownership	Definition of waste	Mandatory recycled content
	(Eco-)modulated Extended Producer Responsibility			



PRIORITY

Adding circulairty to this top of pyramid can bring creativity and visibility to the brand

LOW PRIORITY

These products that generate meduim product turnover are of low priority.

HIGH PRIORITY

The bestsellers are high priority as they will allow the highest environmental impact abatement. It will be most difficult section to work on.

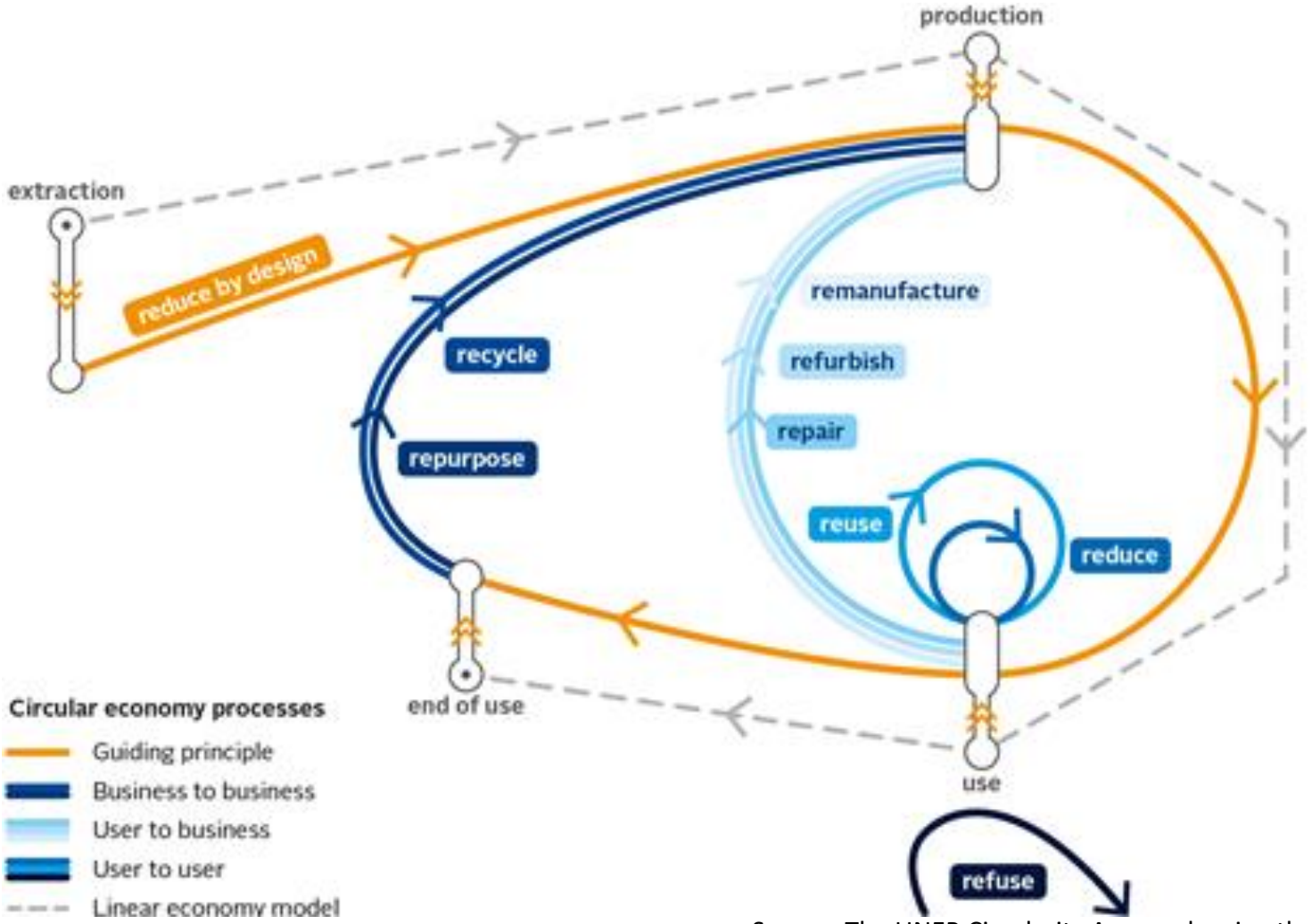
Maximum Priority: All new products that enter the collection should be as circular as possible.

USE A STEP BY STEP APPROACH

Sorting of waste in a circular economy

Johannes Leis | johannes.leis@stfi.de

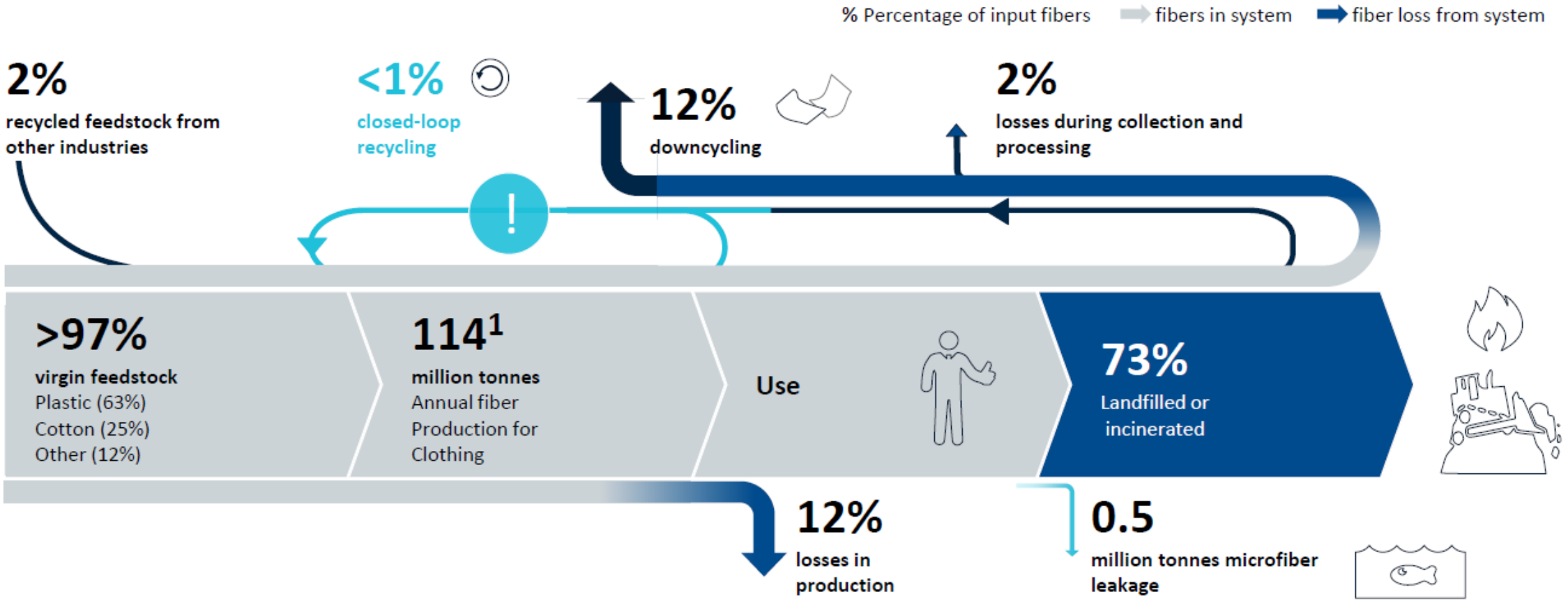
And circular economy is more than recycling



Source: The UNEP Circularity Approach using the 9-R concept

Johannes Leis | johannes.leis@stfi.de

Circularity in fashion



Source: Sorting for circularity, how automised sorting is closing the gap between wasted textiles and recycling, Louisa Hoyes,Tomra, ETP Masterclass

Johannes Leis | johannes.leis@stfi.de

What is collected?

A collection system for textile waste if established for:

- Shoes,
- Clothing,
- House and home textiles.

→ That is mostly post-consumer-waste from private households

Source: www.dw.com/de/mehr-billig-kleidung-im-container/a-45019416

- Production waste and technical textiles not necessarily part of the system
  - → Disposal routes often unknown/not officially determined
  - → Numbers for textile production waste are estimates

Ways for collection of textile waste

Basically 3 ways for collection of textile waste

	Container	Street collection	Others (e.g. retail)
Share (tendency)	85 - 90 % (↑)	5 - 10 % (↓)	1 - 5 % (↑)
Quality of the collected textile products	Mediocre	Mediocre	Good
Danger of incorrect disposals	High	High	Low
Collection volume	Very high	High	Low
Risk of robbery	Low but existent	Existent	Not really existent
Cost (logistics & personnel)	Very good	Good - mediocre	Mediocre

Johannes Leis | johannes.leis@stfi.de

Sorting of textile waste

Source: TEXAID AG, Sortierung

Material

Colour

Quality

Seasonal aspects

Special sorting

Fashion

Goal is a high share of reusable products

Johannes Leis | johannes.leis@stfi.de

Sorting of textile waste

Johannes Leis | johannes.leis@stfi.de

Shift towards more automated sorting

The sensor-based/automated sorting of waste is not an invention of the textile industry.

In other industries with a high proportion of plastics, e.g. in the packaging sector, this has been done for 15 - 20 years and is state of the art.

The main purpose of sorting is different. In other recycling sectors, waste is shredded for better transportation and separation, which facilitates sorting by material fraction.

With textile waste, however, the focus is on reuse, which does not allow shredding.

In recent years, there has been a lot of momentum in the market for automated sorting of textiles, with several players advancing their own developments (incl. SOEX □ excursion!).

→ **Sorting for reuse and sorting for recycling**

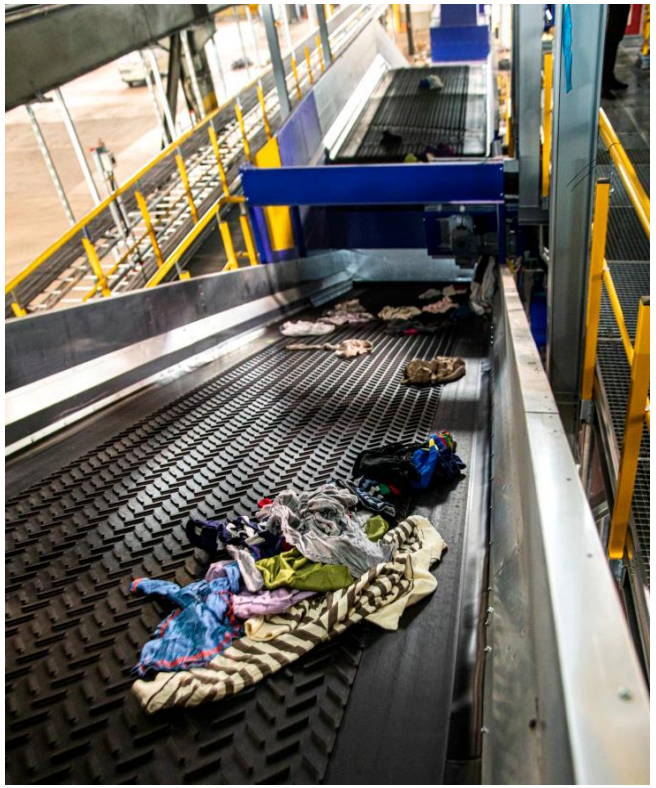
Automated sorting of textile waste

Sorting for reuse vs. sorting for recycling

Examples: Sysav, SOEX, Valvan, TOMRA, Wastex, …

- Technology: NIR, Combination with colour detection

Source: Dr. E. Perzon, IVL, Siptex – the first automated, industry scale sorting plant for textile waste, ETP Strategic Program Circular Economy, 2020



Developments of equipment for automated pre-sorting, masterclass example: Wargön Innovation, Sweden

https://www.youtube.com/watch?v=aJ4ON4aZHJA

Johannes Leis | johannes.leis@stfi.de

Automated sorting of textile waste

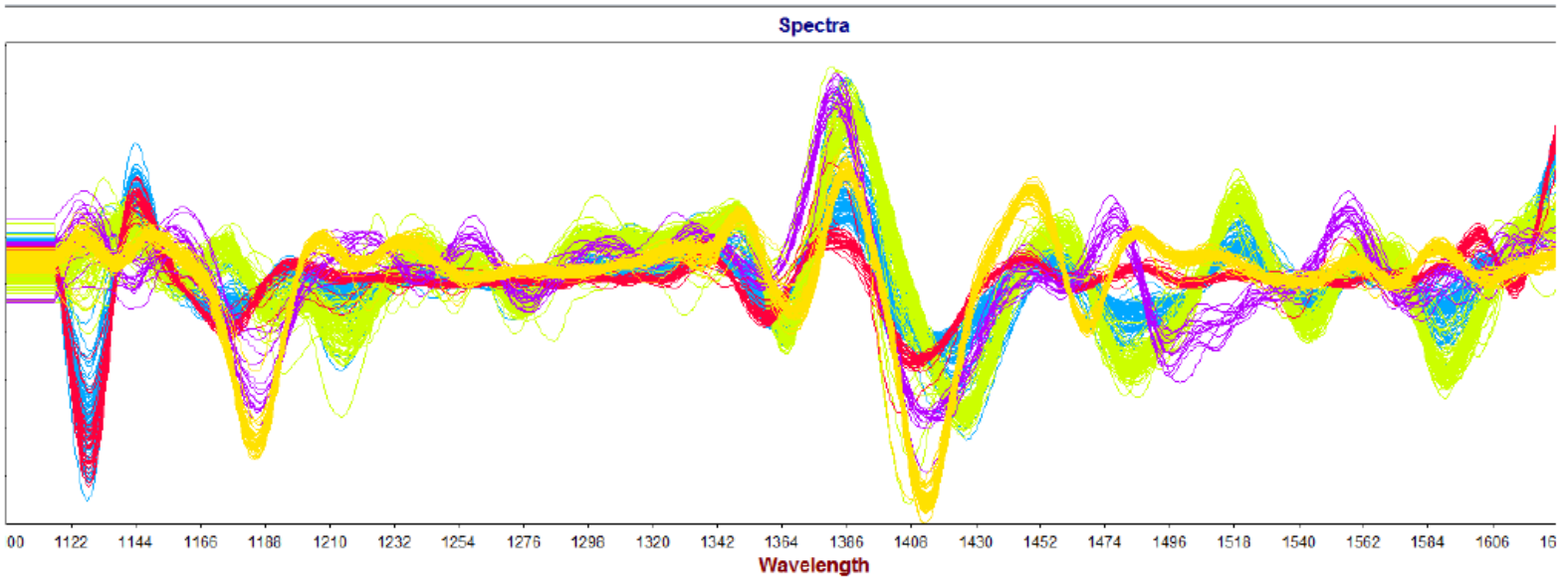
Example Fibersort, Valvan Baling System, Belgium

- Automatically sorting textiles based on **fiber type, color and structure**
- Production rate:
  - 1 sample every 1 second
  - 3.600 samples / hour
  - **1260 kg / hour** (avg weight of 0,35 kg / piece)
- Operators needed:
  - 1 fulltime to feed the line
  - 1 at intervals to bring carts to the line and to take sorted carts away

valvan baling systems

Automated sorting of textile waste - NIR

Near Infrared Spectroscopy – principle



- Cotton
- Acrylic
- Polyester
- Wool
- Cotton - polyester

Can also be combined with other systems, e.g. color sensors, to assign the detected materials.

- ➢ Surface detection, not suitable for multilayered materials
- ➢ Not suitable if radiation is absorbed (carbon black!) or reflected (PTFE!)

Automated sorting of textile waste – SOEX Recycling Germany

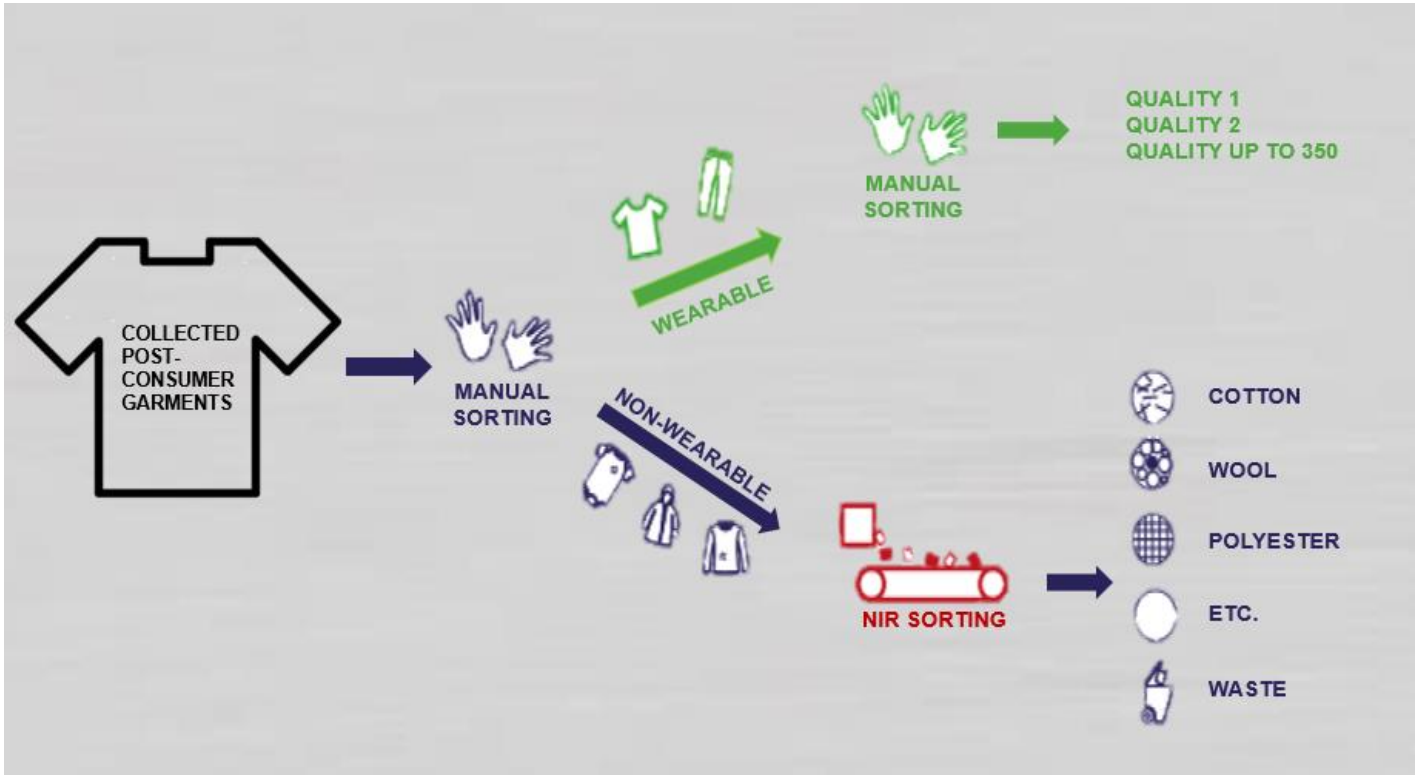
- 1 conveyer belt
- NIR spectrometer with RGB sensor
- Automated operation and sorting

- Sorting capacity: up to 700 kg per hour
- Automatic separation of garments by picking 1.500 pieces per hour (depending on the size and weight of the piece)
- Material recognition technology with 64 sensor points
- Identification of 86 different material compositions (natural fibers / synthetic / blends)

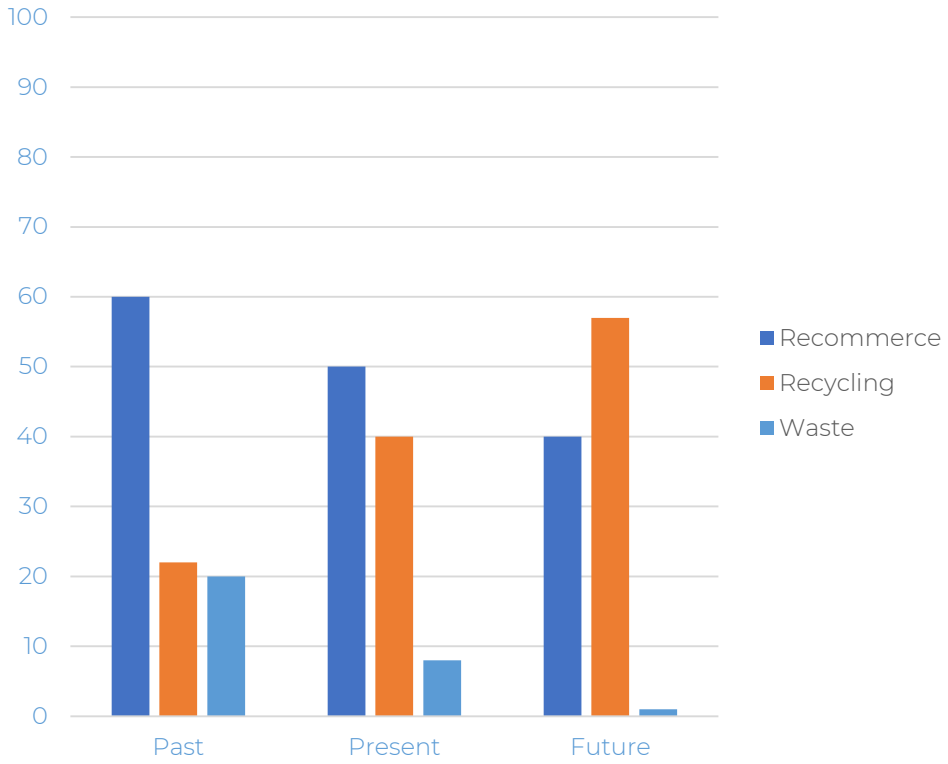
- Evaluation - which material compositions are in demand?
- Integration of the plant into the sorting and production process
- Establishment of an infrastructure / processes for recycling of textile waste

Source: Henrike Schmitz, SOEX Recycling Germany, Textile Recycling – Topics, Trends & Innovations, 2023

RE-SALE & RECYCLING – CURRENT STATUS & OUTLOOK



RESULTS OF SORTING FRACTIONS OF POST-CONSUMER APPAREL AND SHOES



Source: Henrike Schmitz, SOEX Recycling Germany, Textile Recycling – Topics, Trends & Innovations, 2023

RE-SALE & RECYCLING – CURRENT STATUS & OUTLOOK

RE-WEAR 60%

TOP QUALITY 10%

SECOND HAND CLOTHING 43%

SHOES 7%

VALUE 46%

VALUE 47%

RECYCLING 36%

FIBER PULLING 16%

WIPERS 16%

OTHER RECYCLING 4%

ENERGY RECOVERY 4%

VALUE 7 %

Open & closed loop recycling – professional disposal

Source: Henrike Schmitz, SOEX Recycling Germany, Textile Recycling – Topics, Trends & Innovations, 2023

Sorting of textiles – separation of non-textile components

Developments towards automated sorting for purification

- TRIMCLEAN from Valvan as an example
- Also NIR sorting of cut textile pieces as an option

THE NEXT STEP: TRIMCLEAN

PREPARE TEXTILE STREAM FOR

RECYCLING PROCESSES

Latest development for automatic removal of trims:

- Labels
- Zippers
- Buttons

First test results are very promising, industrial tests are planned in Q1 2023.

MORE INFO BY Q2 2023

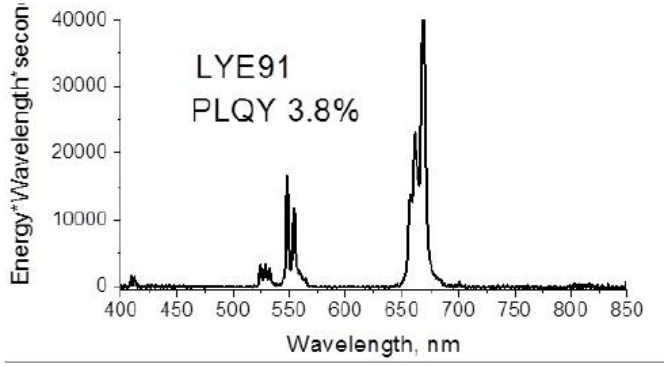
- Sorting makes sense when there is a demand!

Source: Valvan, Gaetane Decloedt, The future of textile sorting, ETP Masterclass, Module 3

Johannes Leis | johannes.leis@stfi.de

Sorting with marker based systems

- Various systems in development (particles, stamps, tags, RFID,…)
- Application to the surface or integration into plastic
- Combination with license/blockchain possible
  - ➢ Could be relevant for recyclates
- Cost factor, contribution to sorting, not recycling itself



Source: Polysecure, Tracer Based Sorting, 3. Fachtagung Composites Recycling and LC

Other examples: FibreTrace, Haelixa, …

Source: The FibreTrace® scanner for the detection of verified material (FibreTrace®, photo: Olivia Repaci)

Traceability, example: Haelixa

Haelixa

Our Solution

MARK

DNA markers containing product information are applied to the fibers, providing a unique identity

VERIFY

At any point in the value chain, the DNA presence is verified through PCR testing

REPORT

After testing, the result is given in a yes/no report. The data can be uploaded to any ERP or digital system

What Makes Us Unique

COMPATIBLE
Markers are applied without altering the composition of the final product & easily integrated into existing processes or machinery

CIRCULAR
Mark pre- or post-consumer waste to prove recycling - the DNA is present in the final product

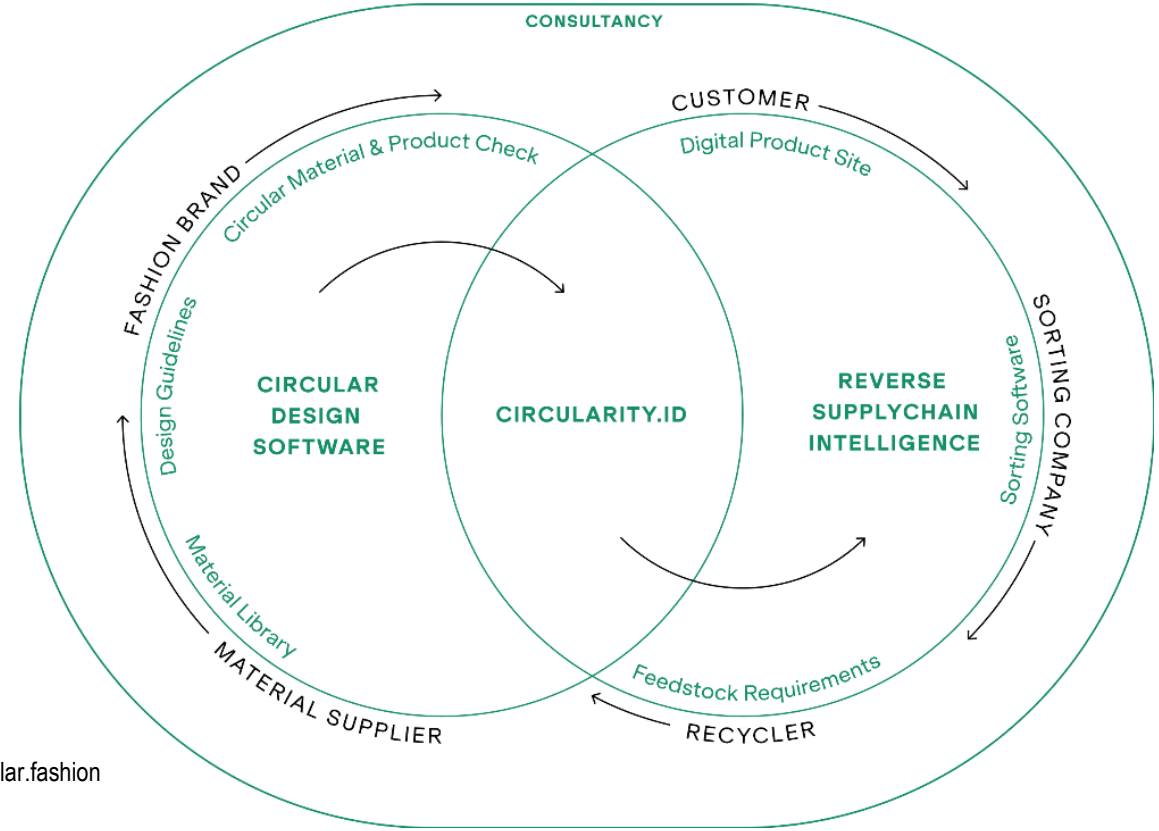
HARMLESS
DNA markers are safe for all applications - GOTS approved, compliant with Standard-100 OEKO-TEX, OCS compliant and GRAS (FDA)

CREDIBILITY
Forensic, data based on PCR testing, to support product claims of origin, processing, recycling, quality, and authenticity

Johannes Leis | johannes.leis@stfi.de

Sorting with marker based systems

Example: circular fashion



Source: www.circular.fashion

Sortierung auf Basis eines Codes

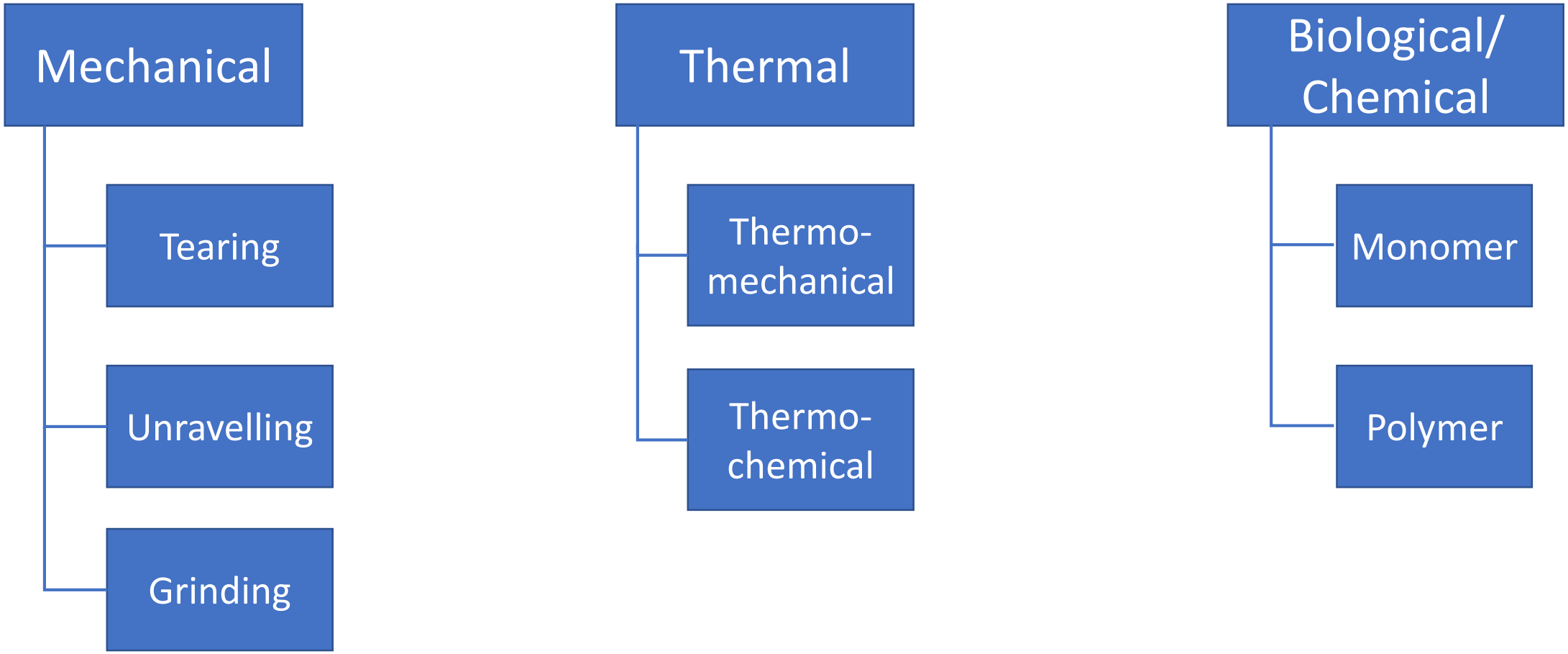
Manual vs. automated sorting or sorting for reuse vs. recycle?

- A lot of momentum in the development of automated sorting systems
- The aim is to supplement manual sorting rather than replace it entirely
- Fashionable aspects and potential as second-hand goods remain a priority
- Example Siptex: operator model as contract sorter
- Sorting is worthwhile where there is (recycling) demand

Textile waste recycling in a circular economy

Johannes Leis | johannes.leis@stfi.de

Recycling technologies for textile waste



Johannes Leis | johannes.leis@stfi.de

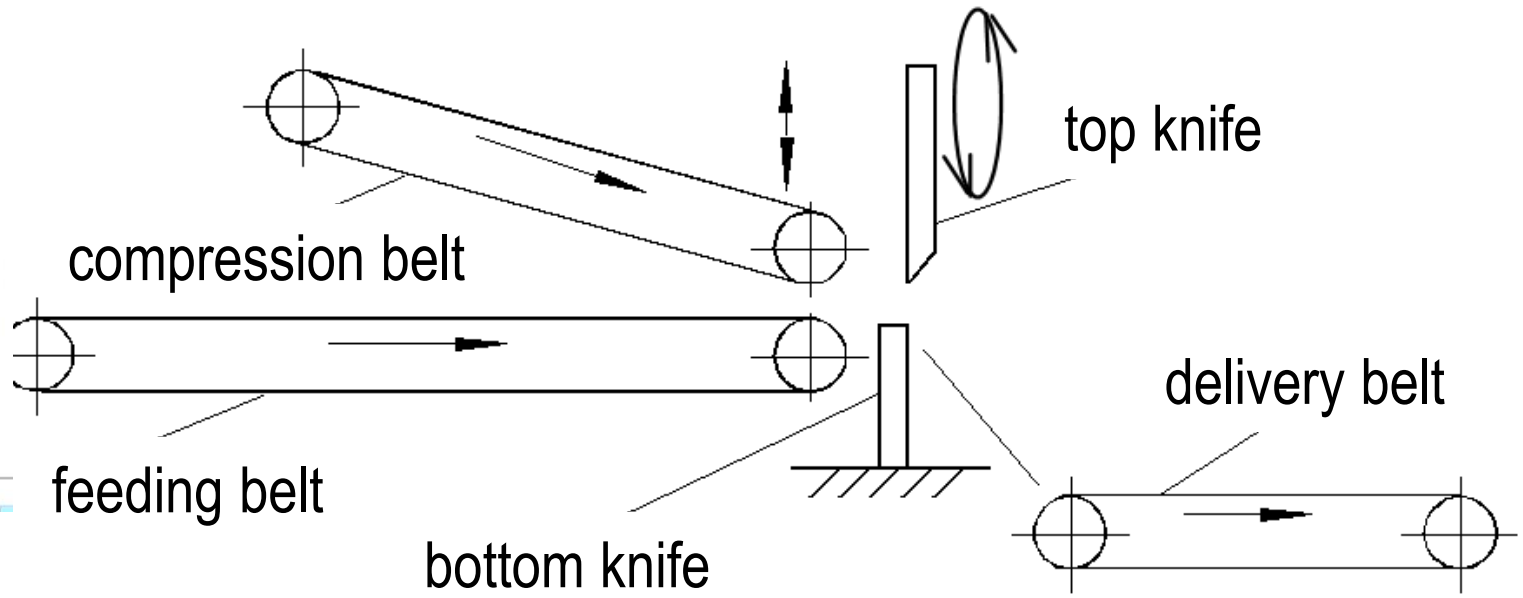
Readiness of the recycling technologies

Technology	Explanation/Comments	TRL today
Open loop mechanical recycling	Mainly for nonwovens industry	TRL 9
Advanced mechanical recycling	Higher share of spinnable fibers	TRL 6 – 9
Thermomechanical recycling	For production waste	TRL 7
Chemical recycling of natural fibers	Primarily cotton	TRL 7 to 9
Chemical recycling of PA	Primarily PA6	TRL 9
Chemical recycling of PET		TRL 4 – 7
Chemical recycling of blends		TRL 5/6
Thermochemical recycling	Pyrolysis, gasification → not yet with textile waste	TRL 9

Source: European Comission, Techno-scientific assessment of the management options for used and waste textiles in the European Union, 2023

Johannes Leis | johannes.leis@stfi.de

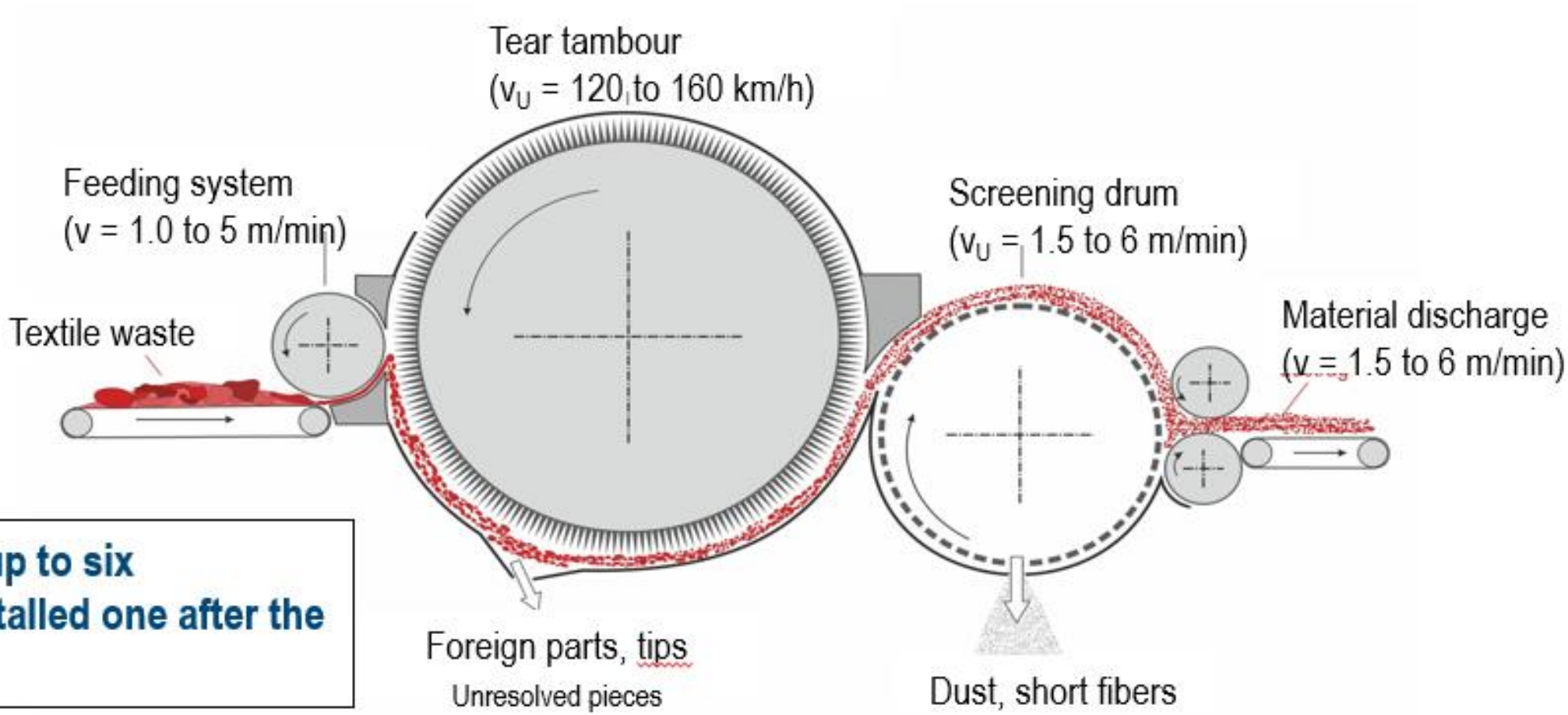
Mechanical recycling of textiles - cutting



Cutting lengths: **3 to 180 mm (special machines up to <1 mm cutting length)**
Working widths: **200 to 800 mm**
Throughput rates: **up to 5000 kg/hour**

Johannes Leis | johannes.leis@stfi.de

Mechanical recycling of textiles - tearing

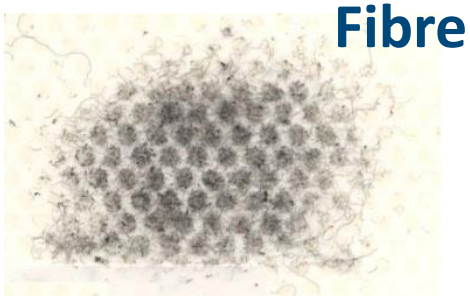


In practice, up to six units are installed one after the other!

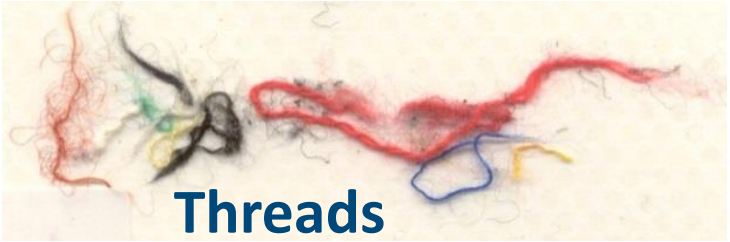
Johannes Leis | johannes.leis@stfi.de

Mechanical recycling of textile waste

Neps

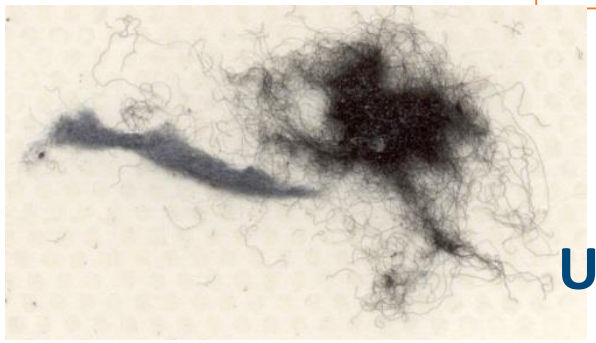


Fibre dust, short fibres



Threads

Reclaimed fibres as a blend of:



Unopened pieces

Fibres with different lengths

Johannes Leis | johannes.leis@stfi.de

Mechanical recycling of textiles - tearing

1 Internal forces and their distribution

2 Homogeneity of the template

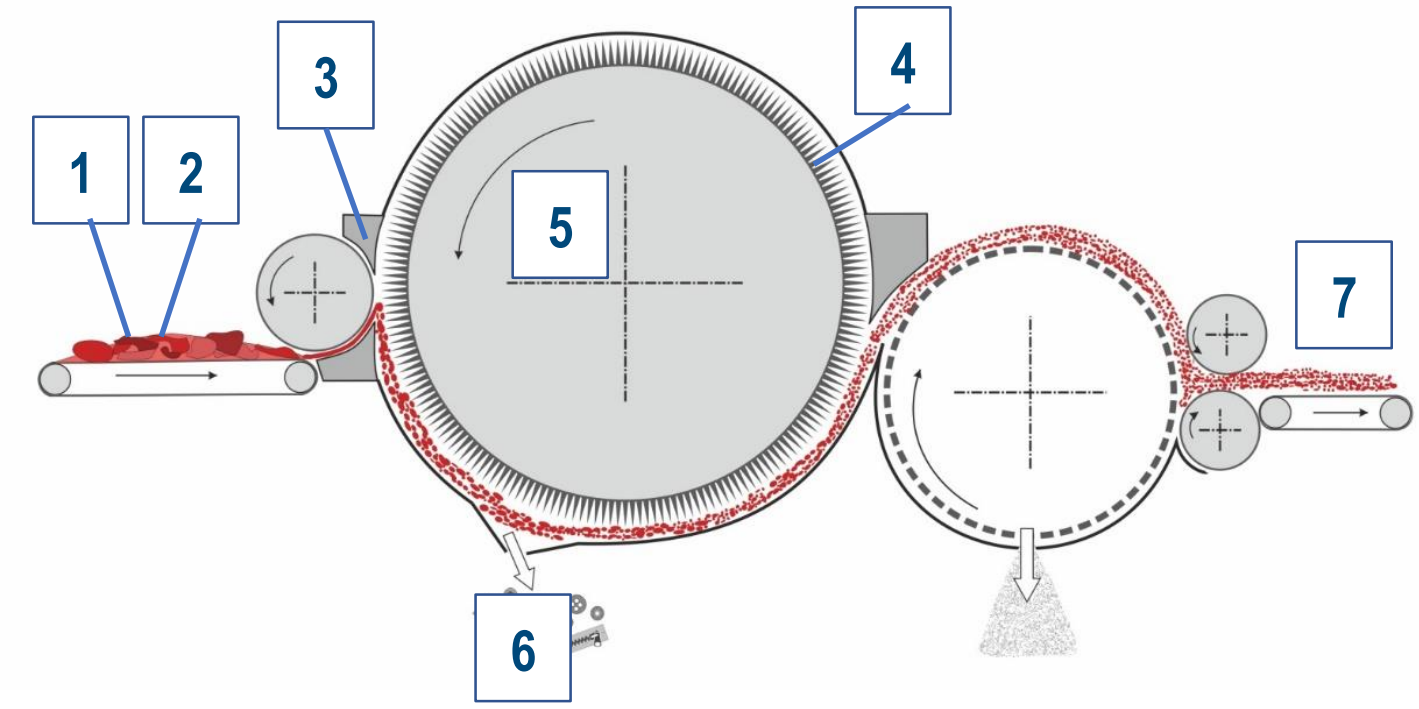
3 Feeding systems and clamping point topography

4 Design, shape and number/ density of the tearing elements

5 Energy input, reel speed

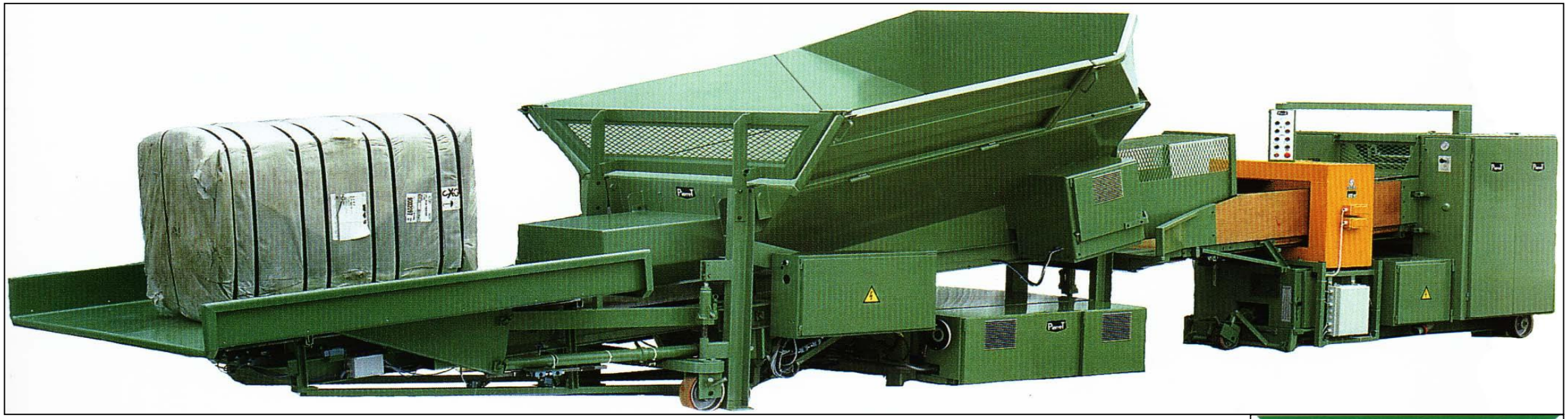
6 Influence of deflashing

7 Number of tearing passages



Johannes Leis | johannes.leis@stfi.de

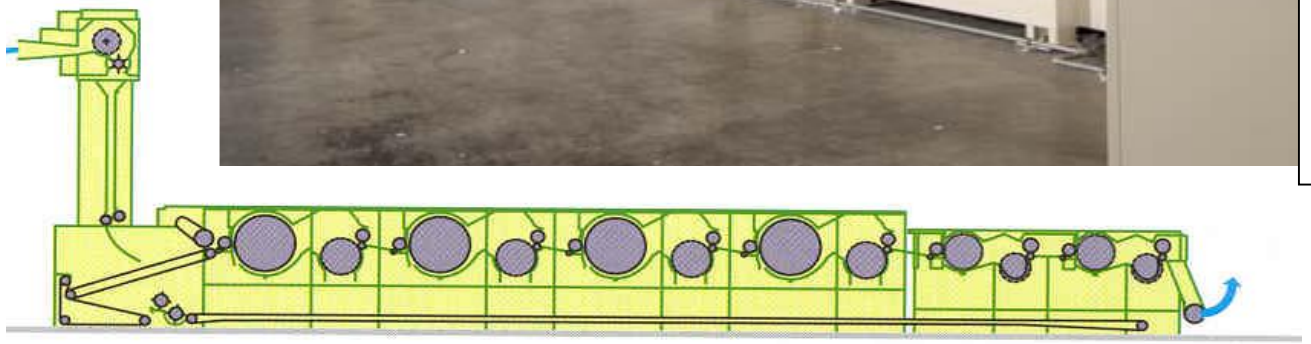
State of the art - cutting



Cutting line „ROBOT“
- Up to 8000 kg/h
- Cutting length: 6 mm to 160 mm

PIERRET INDUSTRIES S.P.R.L., Corbion/Belgium

State of the art - tearing

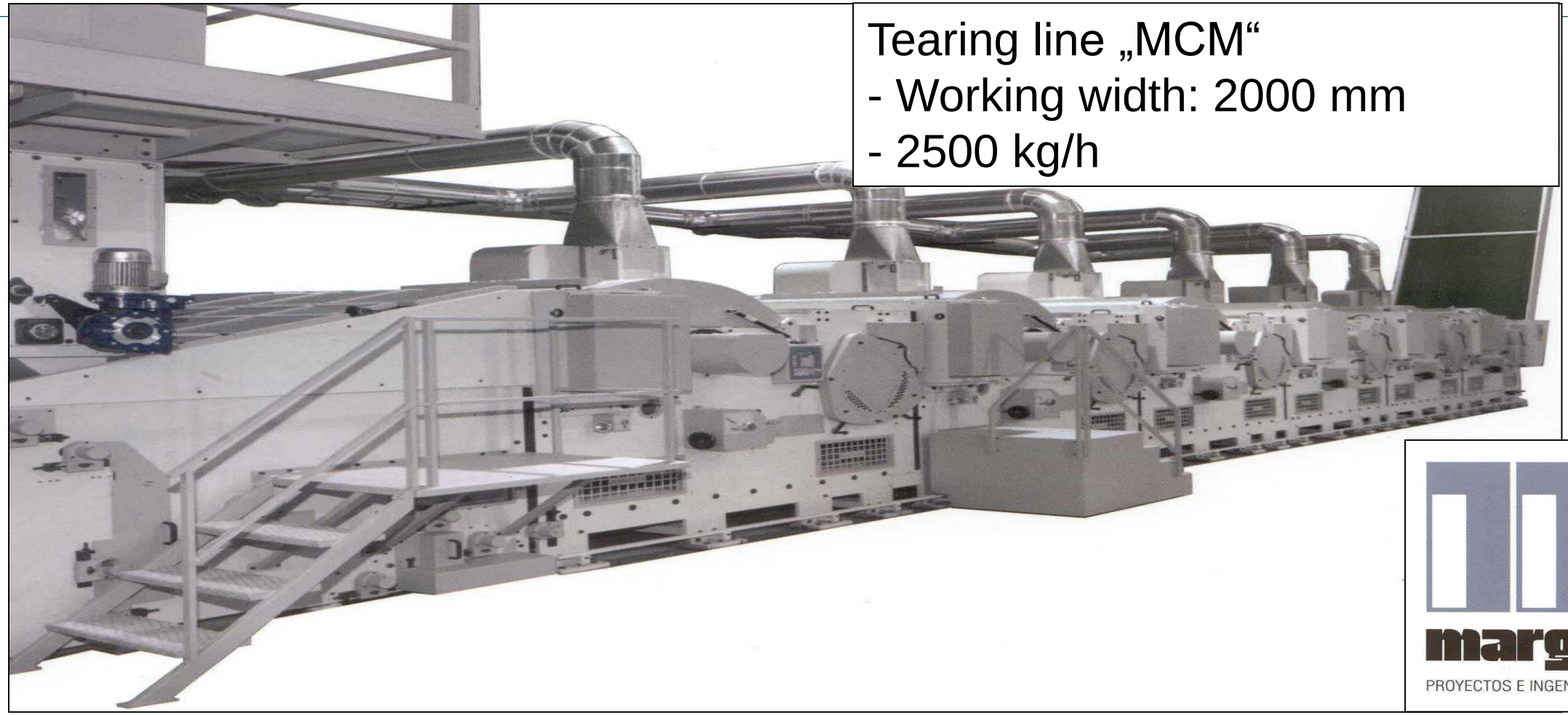


Tearing line „JUMBO + EXEL“
- Working width: 2000 mm
- 1800 kg/h

LAROCHE

LAROCHE S.A., Cours La Ville/France

State of the art - tearing

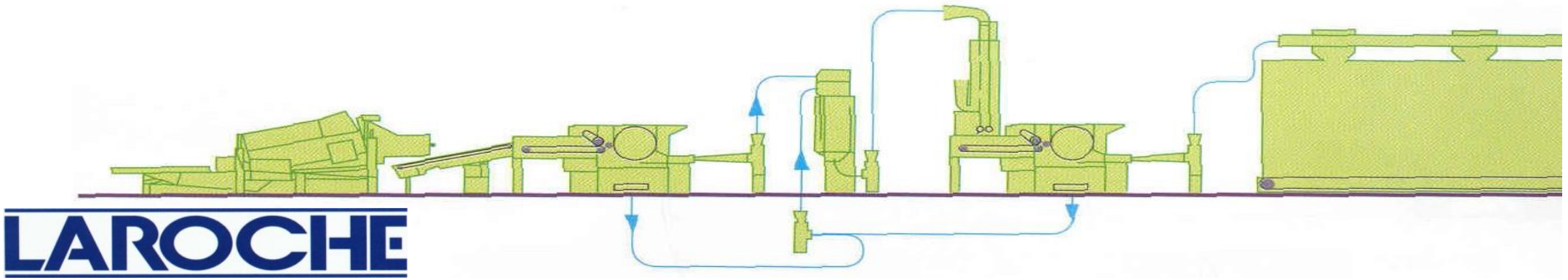


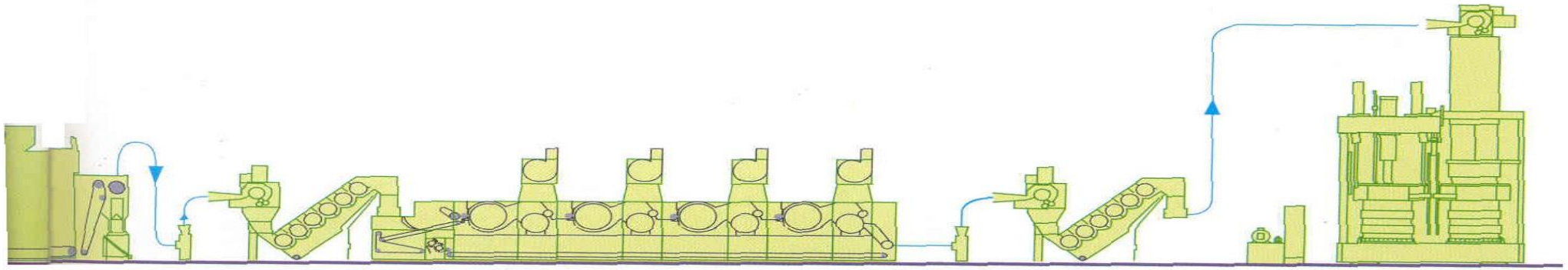
Tearing line „MCM“
- Working width: 2000 mm
- 2500 kg/h

margasa
PROYECTOS E INGENIERIA TEXTIL S.L.

MARGASA S.L., Cerdanyola del Vallès/Spain

State of the art - tearing



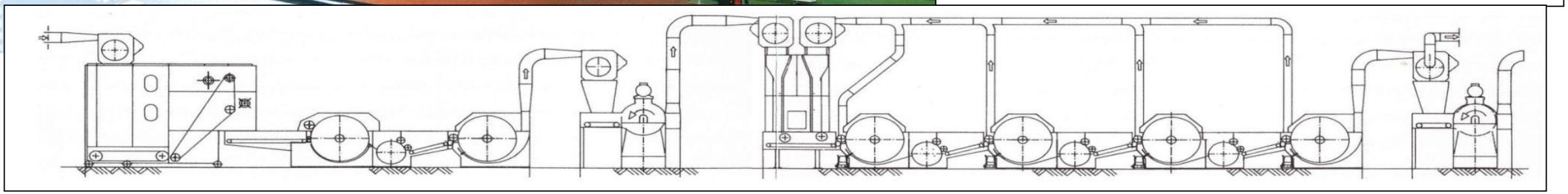


Tearing line „JUMBO“
- Working width 2000 mm
- 2500 kg/h

LAROCHE S.A., Cours La Ville/France

State of the art - tearing

Tearing line „MONDIAL“
- Working width:1900 mm
- 2000 kg/h



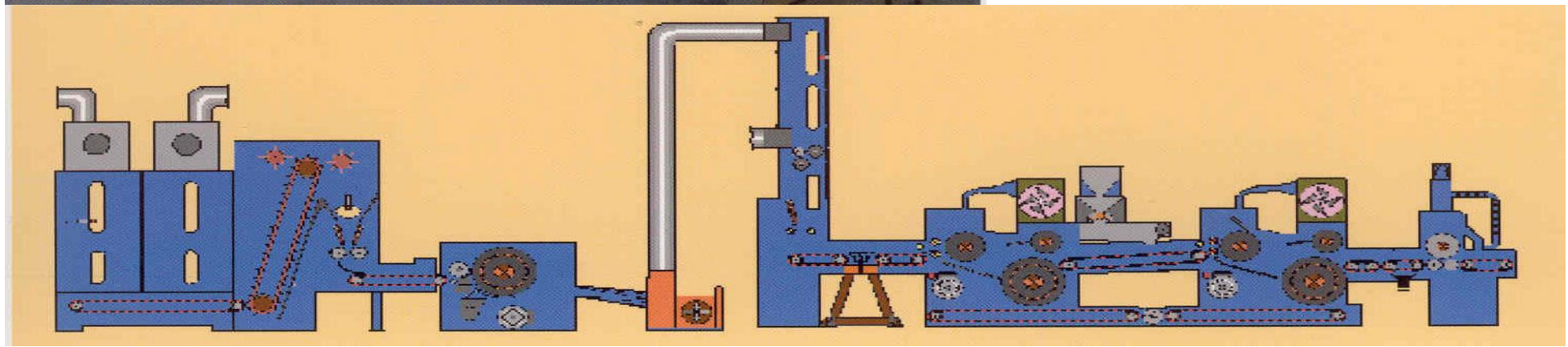
DELL‘ORCO & VILLANI, Capalle/Italy

DELL’ORCO & VILLANI

Processing of the products of the tearing process

Random web plant „FELTECH“
- Mass per unit area:
  300 g/m² - 3000 g/m²
- Working width: 3.2 m
- Up to 2800 kg/h

MARGASA S.L.,
Cerdanyola del Vallès, Spain



margasa
PROYECTOS E INGENIERIA TEXTIL S.L.

ETP
Fibres Textiles Clothing
EUROPEAN TECHNOLOGY PLATFORM

Thermomechanical recycling of textiles

- Pre-treatment, melting, cleansing and filtration of the material
- Any thermoplastic material, but huge differences in achievable properties and share of virgin material needed
- With production waste often close to virgin quality, for Post-Consumer-Textiles so far not an option
  - ➢ Avoid material mixtures
  - ➢ Avoid added chemicals
- EREMA, GNEUSS, Starlinger,…

Johannes Leis | johannes.leis@stfi.de

The project „raw material classification“

DEUTSCHE INSTITUTE FÜR TEXTIL+FASERFORSCHUNG

Open End (OE) yarn, 100% recycled aramid

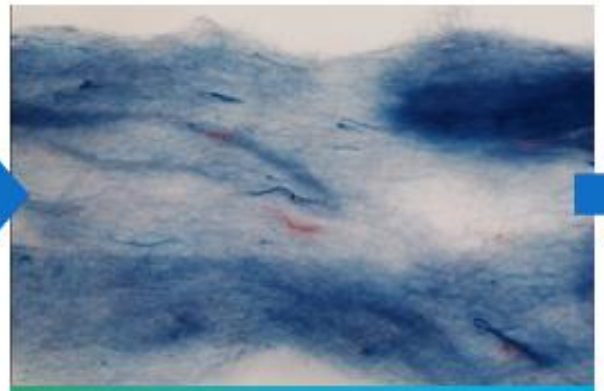
Opening 2 tambours

Card web

Card sliver

Fiber wastage: 63 %

Opening 3 tambours



Card web

Card sliver

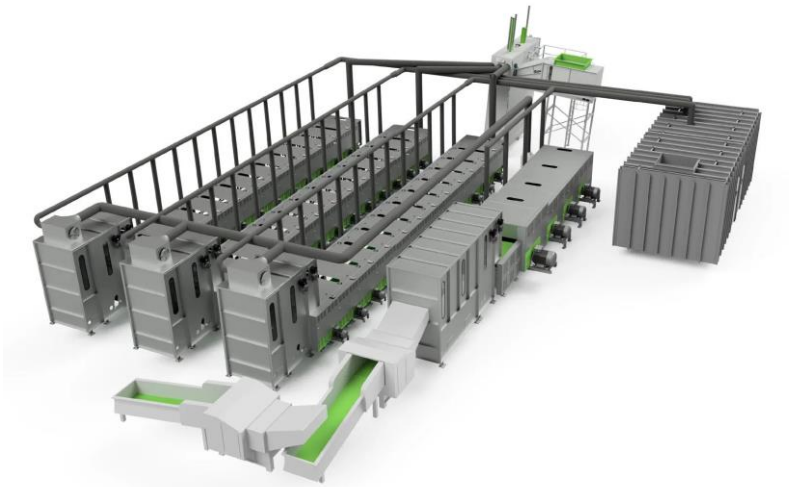
OE yarn

Fiber wastage: 29 %

Johannes Leis | johannes.leis@stfi.de

The goal: higher share of spinnable fibers

Säntis Textiles PTE LTD, Singapur
The RCO100



- 4 pre-openers + 12 fine openers (per line)
- Lower throughput: 300 kg/h/line
- Higher achievable fiber length

Dell'Orco & Villani S.R.L., Capalle
The twin-carding-opener TCO

- 2 cylinders with total of 8 opening positions
- Lower throughput: 500 kg/h
- Higher achievable fiber length

Does the fiber quality justify the lower throughput?

Johannes Leis | johannes.leis@stfi.de

Soft closed loop recycling: Säntis Textiles

RCO100: Yarn Products

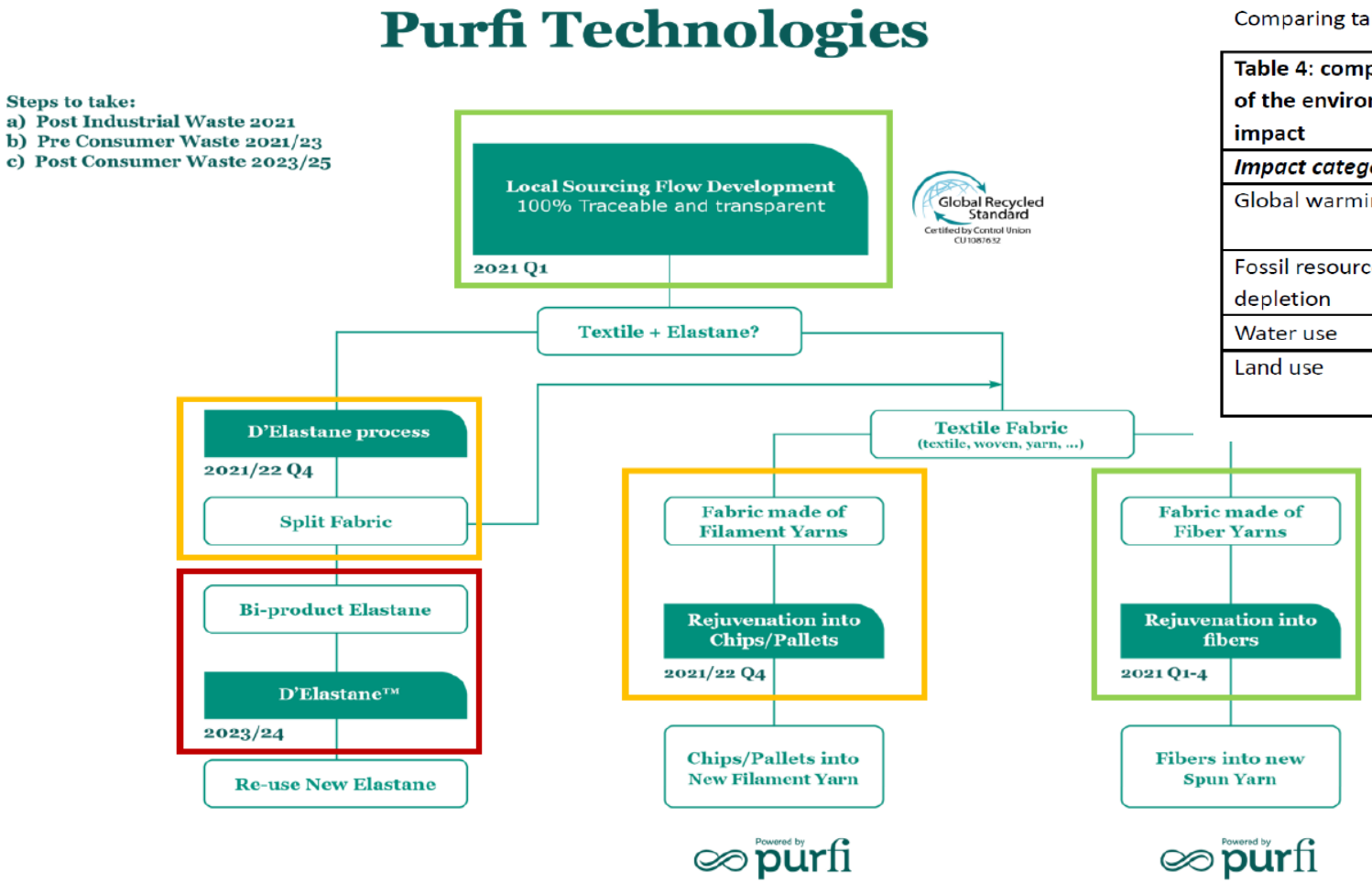
RCO100 recycled cotton yarns are spun with advanced spinning equipment that includes open-end and carded compact ring spinning technology, creating virgin like quality yarns with our 100% high quality recycled staple fibers.

Product	Yarn Count	Construction	Composition
RCO100 Recycled Cotton	Ne 6/1 – 30/1	Compact Carded – Ring	100% Recycled Cotton
RCO100 Rec.Cotton Bio-Based Stretch	Ne 6/1 – 30/1	Core Spun – RS (40D, 70D, 100D)	94% Rec. Cotton 6% Creora
RCO100 Recycled Cotton	Ne 6/1 – 20/1	Open-End (OE)	100% Recycled Cotton

- Maximum 10 to 15% staple length loss in the pre-consumer recycling process
- Maximum 15 to 20% staple length loss in the post-consumer recycling process
- Pure mechanical process. RCO100 yarn strengths are slightly below virgin cotton when using industrial waste.
- Based on Turkish virgin cotton with 30-32mm we achieve from yarn waste 26-28mm staple length

Source: Stefan Hutter, Säntis Textiles, Circular and Biobased Textiles Innovation Hub, Textiles ETP, 07.07.2024

Soft closed loop recycling: Purfi



Comparing tables 3 and 4 gives the following savings when using rejuvenated Purfi cotton:

Table 4: comparison of the environmental impact	Per 1000 kg of virgin Indian cotton fibers	Per 1000 kg cotton by Purfi rejuvenation			
Impact category	***Value***	***value***	***Savings***	***Unit***	***%***
Global warming	2349	404	1945	Kg CO2-eq	83
Fossil resource depletion	281	123	158	Kg oil eq	56
Water use	801	2	799	m^3	99.7
Land use	9721	12	9709	m^2yr crop eq	99.9

Source: Purfi, Koen De Ruyck, closed loop soft recycling, ETP Masterclass – Module 3

Johannes Leis | johannes.leis@stfi.de

Material examples: mechanically recycled cotton

Today reclaimed fibres are used almost exclusively in nonwoven products for insulation, upholstery and automotive textiles. But we see a trend towards applications in yarns (again)

- Design study: towels and shirts made from organically grown cotton

Yarn made of 80 % rCO / 20 % CO

Source: Kerstin Jost-Eisenberg, www.jost-eisenberg.de

Material examples: mechanically recycled wool

Recycling trials at STFI

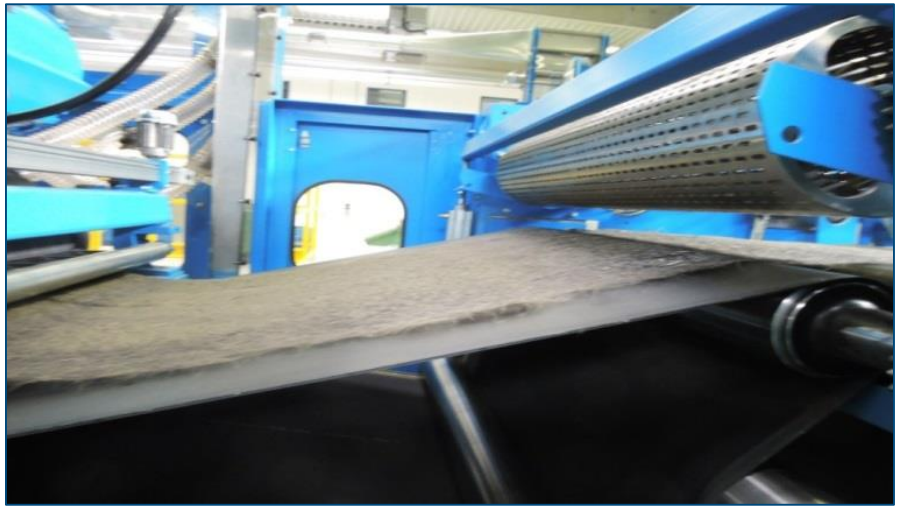
- Cutting & tearing
- 6 wool weaves & 1 felt
- Felt as a strongly consolidated material
  → resulting fiber lengths
- Threads/yarns
- Lamination adhering

Conclusions for the design:

- The recycling of production waste appears to be easily possible, at least in a mixture
- Post-consumer with additional requirements
- To be considered → Burdens due to use
- Alternatives to lamination?

Material examples: mechanically recycled carbon fibers

- Preparation of dry carbon fibre waste is technically proven and economically useful
- Recycled fibres are processed by mechanical web formation (carding principle or random laid web formation) using 100% recycled carbon fibres or blended with other fibres and subsequent mechanical bonding
- Carbon fibre nonwovens show a property profile qualifying them for lightweight applications

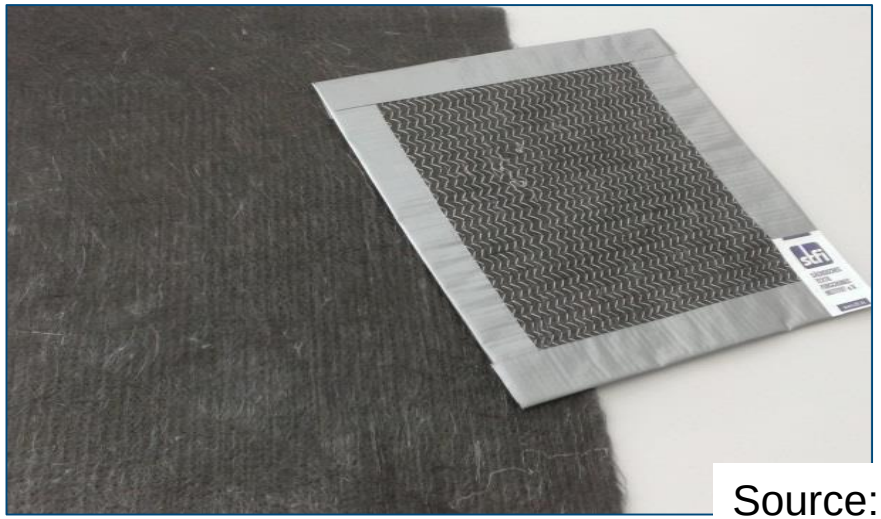


DEUTSCHER ROHSTOFF Effizienz Preis

Source: STFI

ETP Fibres Textiles Clothing EUROPEAN TECHNOLOGY PLATFORM

Material examples: mechanically recycled carbon fibers



Source: STFI

Chemical recycling of textiles

- Recycling of polymers or monomers using chemistry
- Not yet very established, but a few commercialised processes exist
- Input does not control output as much. However, color, material, auxiliaries, fiber length (and others) might be important. Proper collection and precise sorting are key.
- Output is of higher restored quality → resource consumption is very often higher

Södra	Infinited Fiber	Renewcell	Lenzing	Carbios	Rittec	Mistra	DEMETO	Asahi Kasei	Fraunhofer
CO	CO	CO	CO	PES	PES	PET	PET/PA6	PA66	PA6

Johannes Leis | johannes.leis@stfi.de

Chemical recycling of cellulose-rich textiles, example: Infinited Fiber Company

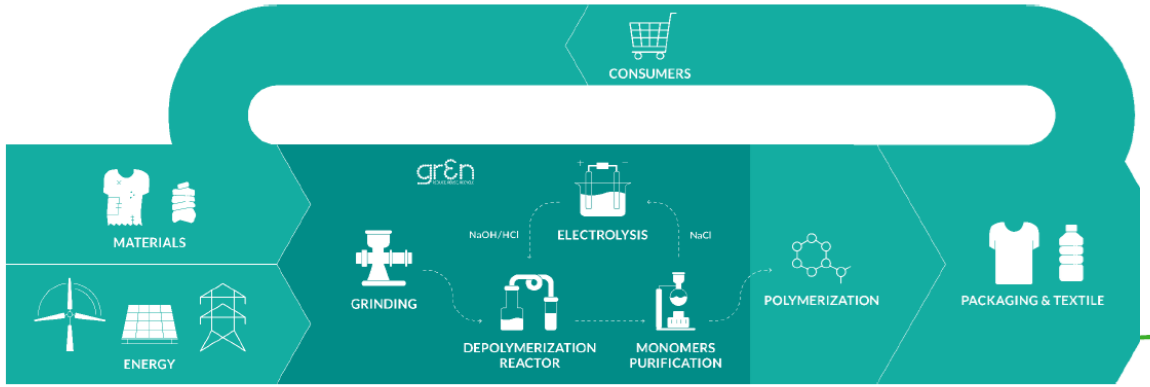
Source: Infinited Fiber Company, Paula Sarsama, Making textile circularity an everyday reality through closed loop chemical recycling of cellulose-rich textile waste

Johannes Leis | johannes.leis@stfi.de

Chemical recycling of Polyester textile waste, examples: Gr3n and RITTEC Umwelttechnik

Gr3n

The core | Depolymerization process



No massive pre-treating needed (e.g., cleaning and drying) as we feedstock is going into the reaction vessel

Electrolysis is the enabling technology to make the process **circular** and **profitable**

The **output** of the de-po plant are **TPA** and **MEG**, be re-polymerized to clo

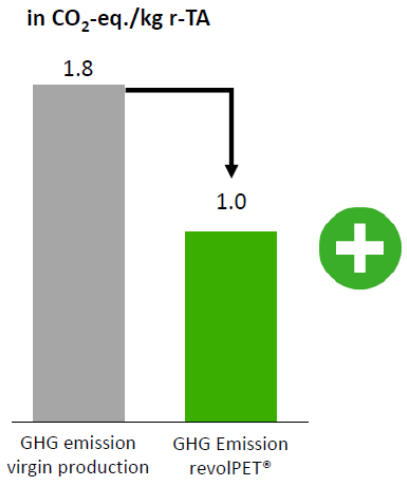
Source: Gr3n, Dr. Fabio Silvestri, Is there a sustainable solution for textile-to-textile-recycling? ETP Masterclass – Module 3

Source: RITTEC Umwelttechnik, Carsten Eichert, Efficient extended producer responsibility: back-to-monomer-recycling as key solutio

RITTEC Umwelttechnik

revolPET® technology

Competitiveness is the benchmark



KPIs

- Process temperature: 120° to 160°C
- Yield: 97%
- Depolymerisation time: < 1 Minute
- No solvents, no catalysts
- All kinds of PET/polyester waste

Main characteristics

- Stable and continuous process
- Energy efficient; low process temperature; complete use of exothermal energy; most of "waste" fractions can be recycled further
- Use of scalable standard equipment
- r-monomers are drop-in-ready to substitute fossil based monomers
- PET from r-monomers has food- grade quality
- Return on Sales at 10% (price base: virgin monomers, no recycling premium!)

Johannes Leis | johannes.leis@stfi.de

Summary

- There are effective recycling solutions for a wide variety of textile waste, but besides further development we also need incentives for a circular economy
- To a similar extent as textile products continue to develop, this must also apply to textile recycling
- There will be room for the different technologies
- We need progress on all stages: materials, effective technologies (recycling and processing), legislation, consume, care, collection, sorting, …
- „The way is still a long one but we started walking“ → high dynamic in many fields

Johannes Leis | johannes.leis@stfi.de

Future fiber market in a circular economy

Johannes Leis | johannes.leis@stfi.de

Recent changes in textile fiber production

FIBRE PRODUCTION				
in ,000 tonnes	2008	%	2018	%
NATURAL FIBRES				
Coir	1,056	1.4	970	0.9
Cotton Lint	23,584	31.4	26,120	23.5
Flax fibre et al.	533	0.7	310	0.3
Hemp fibre & tow	61	0.1	70	0.1
Jute, Kenaf et al.	2,588	3.4	2,500	2.2
Sisal et al.	295	0.4	210	0.2
Silk, raw	164	0.2	164	0.1
Wool, clean	1,198	1.6	1,080	1.0
Other fibres	1,076	1.4	780	0.7
Total Natural	**29,479**	**40.7**	**32,200**	**28.9**
MANMADE FIBRES				
Cellulosic fibers	3,464	4.6	6,900	6.2
Synthetic filament	25,750	34.3	49,800	44.7
Synthetic staple	15,331	20.4	22,400	20.1
Total Manmade	**44,545**	**59.3**	**79,100**	**71.1**
TOTAL FIBER	**74,024**	**100.0**	**111,300**	**100.0**

Source: DNFI

Source: Textile Network, global fiber production, 2020

Johannes Leis | johannes.leis@stfi.de

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Source: Textile Network, global fiber production, 2020

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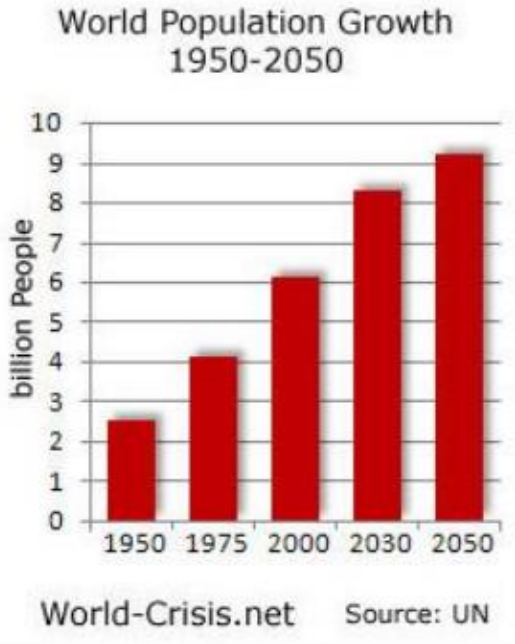
Developing demand for textile fibers

Increasing textile fiber demand



Textile fiber consumption
Europe: 20 kg/capita
World: 12 kg/capita

Due to a growing world population and increasing prosperity the global textile fiber demand is expected to have increased 2-3 times from today's 100 million annual metric tones by the year 2050.

Source: Hanna de la Motte, RI.SE, ETP Strategic Program, 2020

Johannes Leis | johannes.leis@stfi.de

Biobased Materials - fibers

- First biobased polymers are available on the market
  - ➢Mainly with comparable properties to PET/PES, PP, PA
- Questions about:
  - ➢Mass availability
  - ➢Feedstock
  - ➢Price
  - ➢Performance
  - ➢Processability
  - ➢Biodegradability
  - ➢Ecologic Impact

- Range of bio-based materials already commercially available, but at high(er) cost and some not yet optimized for textiles

Name	Price indication	Bio-based ?	Intrinsic suitability for fibres
Bio-PA	€€€	Up to 100%	++: current PA is limitedly used for textiles
PBAT	€€ - €€€	Not, partially (up to 50%)	+: processing; use as additive
PBS	€€ - €€€	Not yet but up to 100% in near future	=: processing ok but low melting point limits (technical) applications
PEF	€€€	100%	++: better than PET properties
PET drop in	€	Only partially	+: as normal PET
PHA	€€€	100%	+: wide range of properties within the 'PHA-family'
PLA	€	100%	++: close to/in-between PP and PET properties
PTT	€€	Partially	+: similar to normal PET
TPS – Starch blends	€€ - €€€	Up to 100%	=: limited durability, low strength

Source: bio-based thermoplastic textile fibers, Lien van der Schueren, Centexbel, ETP Masterclass

Johannes Leis | johannes.leis@stfi.de

Biobased Materials

BIOBASED COLOURANTS

Huge range of biobased colourants

- Caprowax (range)
- Archroma earth colours (range)
- Tannin (ocher-yellow)
- Chlorophyllin (green)
- Curcumine (yellow)
- Indigo (blue)
- Carmin (red)
- Carotene (orange)
- Riboflavin, vitamin B2 (yellow)
- Onion peel extract (green)

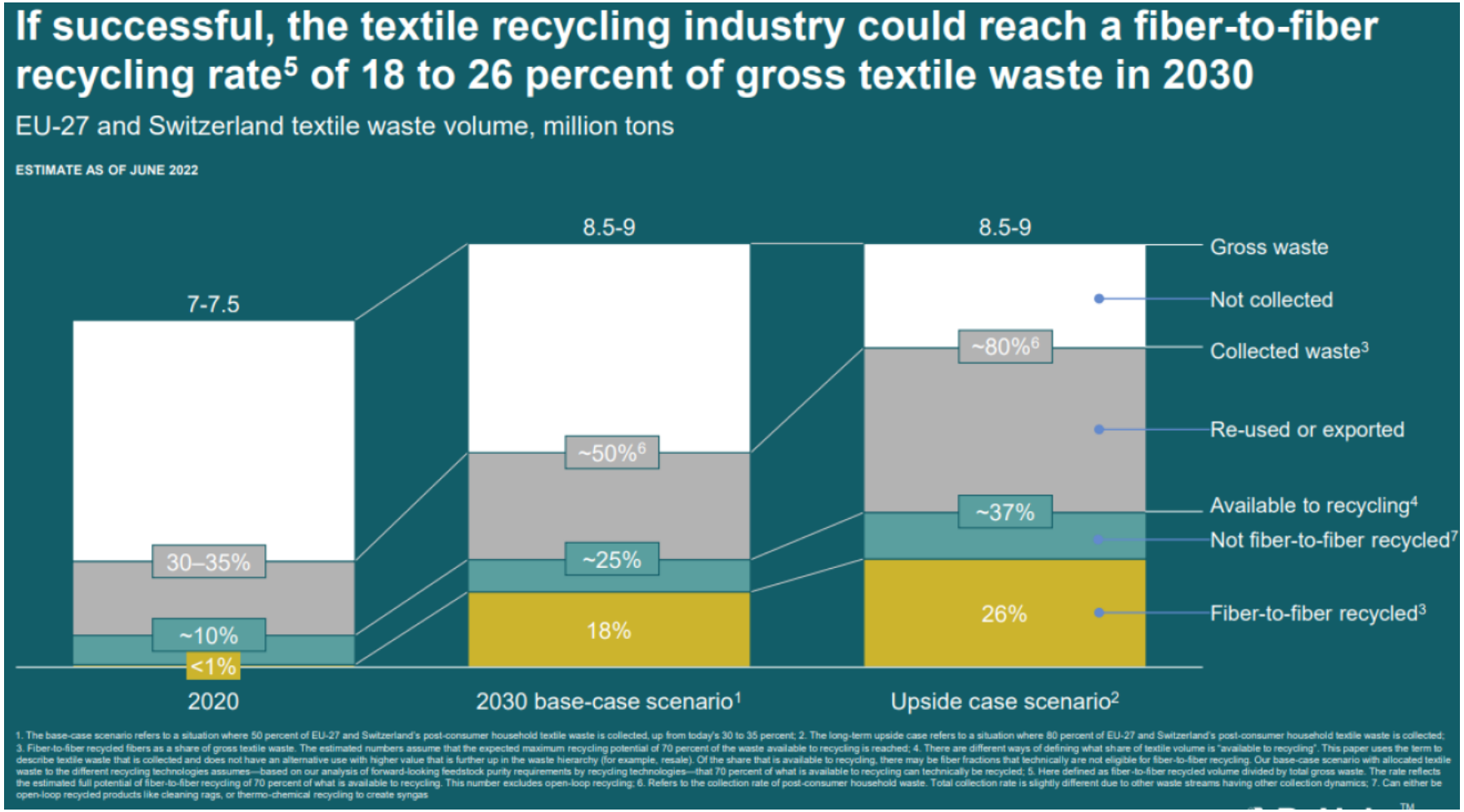
Source: bio-based colourants and flame retardants, Willem Uyttendaele, Centexbel, ETP Masterclass

There is a lot going on!

- **Similar questions to fibrous materials**

Johannes Leis | johannes.leis@stfi.de

Secondary materials market in the European textiles industry



Source: ReHubs Stakeholder Forum, 22.11.2022

Johannes Leis | johannes.leis@stfi.de

Thank You

Contact:

manisha.marival@ceti.com

johannes.leis@stfi.de

Ceti TRANSFORMATIVE TEXTILES

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