ENTeR - Expert Network on Textile Recycling

High Level Training - Workshop RE4TEX / Chemnitz (DE) / 13.11.2019

Introduction

INTRODUCTION

Innovative services require educated people with versatile skills. To support this, one of the main outputs of the ENTeR project is the development of High Level Training Modules. Within the WP3 “Approach & Validation” relevant Training Paths have been identified and training modules have been elaborated using the experience and knowledge of the project partners. The training material can be used either as self-leaning or e-learning courses as well as for real training courses. Target groups are entrepreneurs, technicians, high level students and authorities.

The training course has a modular structure and can be adapted to the needs of the participating target groups. The following single modules are available:

INTRODUCTION – TRAINING PATHS

Training Path	Title
1	ENTeR project and M3P platform with its functionalities
2	Strategic Agenda including Regional Analysis and Action Lines
3	Main textile recycling technologies and methods to recover, reuse and recycle textile waste
4	Projects and networks (national and European) related to textile recycling including research trends and needs coming from the industry
5	Technical and economic findings from the Pilot Cases and professional profiles
6	Eco-design techniques applied to textile processes

High Level Training

Training Path1 - Circular Economy & Tools from ENTeR

Author: Project partners CENTROCOT & UNIVA (IT)

MODULE 1 – CIRCULAR ECONOMY & TOOLS FROM ENTER PROJECT

Foreword

Interreg Central Europe Programme and ENTeR project

Introduction

Sustainability, Circular Economy and Industrial Symbiosis

Resources & Tools

available from ENTeR project

M3P Platform

Interreg Central Europe Programme

(https://www.interreg-central.eu/Content.Node/home.html)

This course has been developed within the ENTeR project (CE 1136) thanks to the funding received from the European Union under the Interreg Central Europe Programme (2nd call 2016).

ENTeR Expert Network on Textile Recycling

The **ENTeR project** focuses on waste reduction of textile sector to prevent depletion of non-renewable resources.

The approach is based on **collaboration** between textile companies and **regional innovation systems** to find:

- new green markets for scraps/waste;
- recycling opportunities for textile materials;
- alternative solutions to raw materials.

ENTER OBJECTIVE

To demonstrate the benefit of an **operational collaborative model** (“virtual centre”)

between research and business partners,

based on **shared skills and know-how**

focused on circular economy, waste eco-design and resource efficiency.

ENTER PARTNERSHIP

Textile Cotton and Clothing Centre

Industrial Unione of the Province of Varese

Pannon Business Network Association

INNOVATEXT Textile Engineering and Testing Institute Co.

Saxon Textile Research Insitute

SACHSENTEXTIL e V.

INOTEX LTD

CTPT - Czech Technology Platform for Textile

Textile Research Institute

PIOT - Federation of Apparel & Textiles Industry Employers

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SUSTAINABILITY

It refers generally to the capacity for the biosphere and human civilization to coexist

- meeting the needs of the present
- without compromising the ability of future generations to meet their needs

3 **P**illars:

- Economic ➔ **P**rosperity
- Environmental ➔ **P**lanet
- Social ➔ **P**eople

Expected results

Social benefits

- *Better standard of living*
- *Increase occupation (green jobs)*
- *Cultural change (sharing economy)*

Economic benefits

- *Reduction of costs for raw materials and energy and for waste disposal*
- *Creation of a business network*
- *New market opportunities*

Environmental benefits

- *Optimisation of resource consumption*
- *Reducing environmental impact and emissions*
- *avoid landfilling*

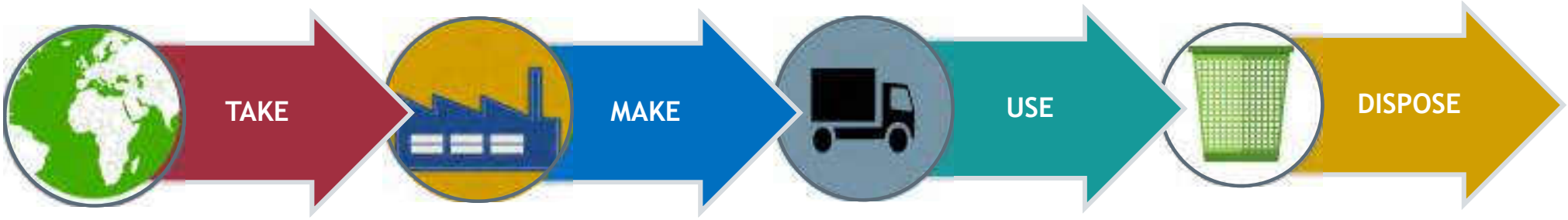
WHAT IS SUSTAINABILITY

Watch the video

LINEAR ECONOMY

Traditional linear economy

In a linear economy raw materials are extracted or cultivated, and then processed into a product that is thrown away after use.



Textile Sector:

The textile sector traditionally follows this model, the main phases are:

Extraction, Cultivation	Manufacturing (Industrial processes)	Distribution, Use, Maintenance (Consumer phase)	Landfill, Incineration (End of Life)

CIRCULAR ECONOMY

A circular economy is fundamentally different from a linear economy.

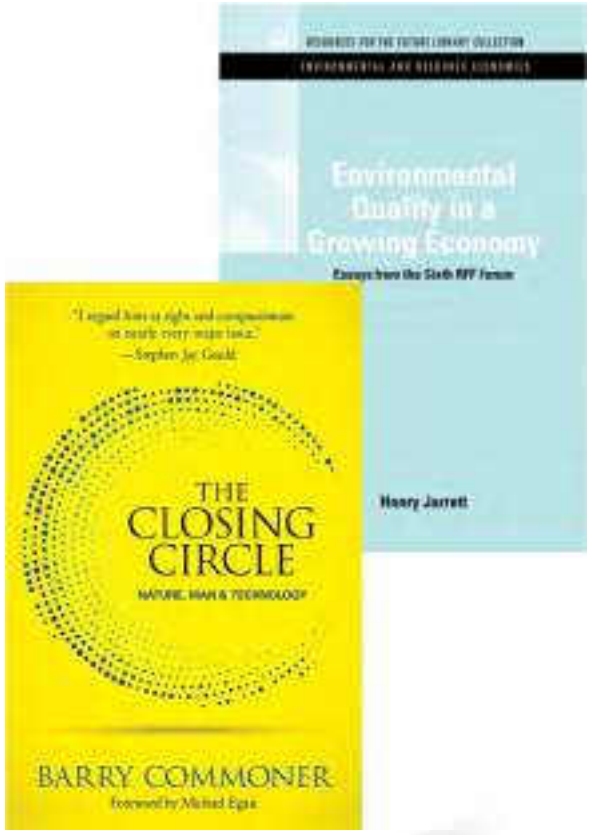
In a circular economy the cycles of all raw materials are closed.

Closing these cycles requires much more than just recycling.

It changes the way in which value is created and preserved, how production is made more sustainable and which business models are used.

Is Circular Economy a new concept?

- K. Boulding, The economics of the coming Spaceship Earth (1966)
- **Barry Commoner, The Closing Circle** (1972)



Awareness of

limits of current growth model

is now part of

the cultural background of

many opinion makers

Circular Economy in the European Union

- Closing the Loop - An EU action plan for the Circular Economy
  (COM(2015) 614 final, 02/12/2015)

- Circular Economy Package
  (Direttiva (UE) 2018/851, 30/05/2018)

Watch the video

Connecting Economic & Environmental Gains

As citizens across the globe aspire towards a **better standard of living**,

- **competition for resources** is growing rapidly,
- with subsequent immense and unsustainable **pressure on our natural environment**

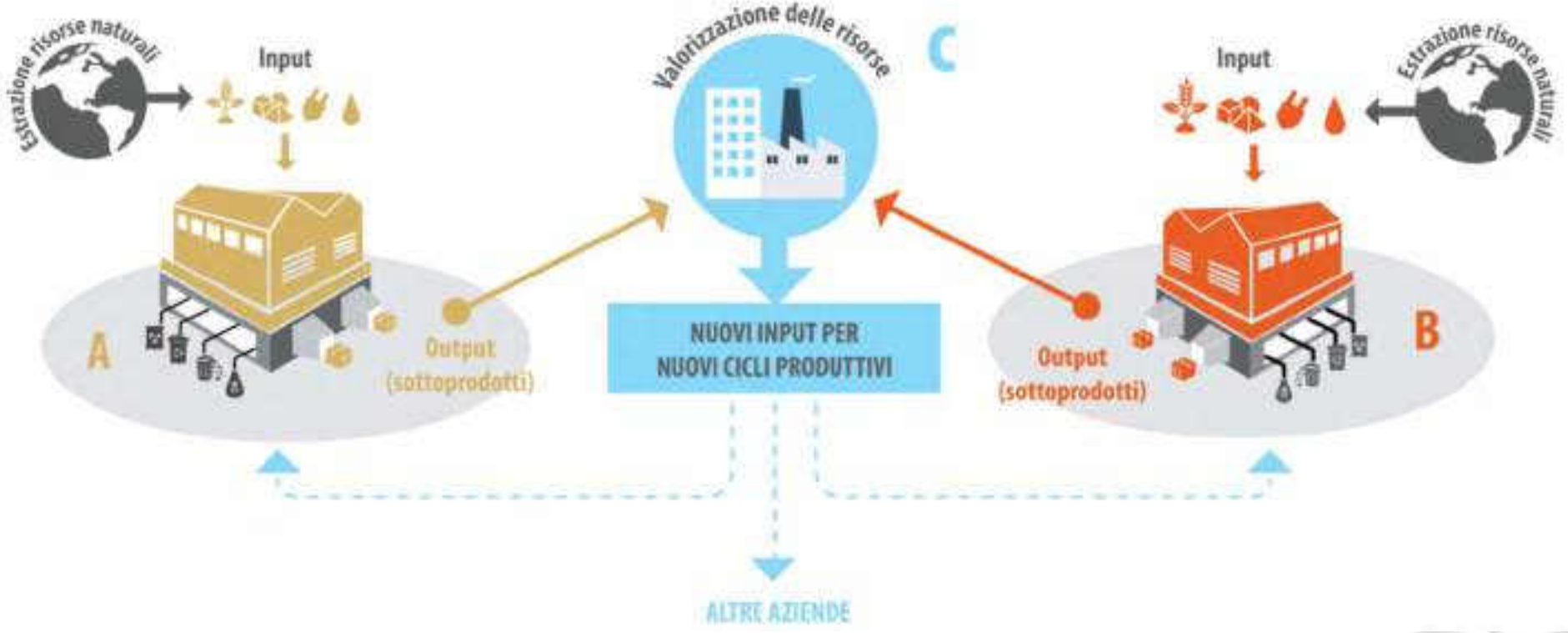
CIRCULAR ECONOMY & INDUSTRIAL SYMBIOSIS

Several different areas of R&I policy are already supporting the transition to a circular economy

- Catalysis to eliminate pollutants and to convert carbon dioxide
- Industrial biotechnology
- **Sustainable process industry**
- **Waste and resource management**
- **Closed-loop manufacturing systems**
- **Water in the circular economy**
- The circular bioeconomy

INDUSTRIAL SYMBIOSIS

Industrial symbiosis is the process by which waste or by-products of an **industry** or **industrial** process become the raw materials for another



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M3P Platform

RESOURCES & TOOLS

available from ENTeR project

- Action Lines - Strategic Agenda
- Pilot Cases ➔ Best practices
- Training Path ➔ Lifelong Learning
- M3P Platform ➔ Database
  - Wastes
  - Technologies
  - Best practices

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M3P Platform

Material Match Making Platform

An online platform for the cataloguing, use and exploitation of industrial textile waste.

This system help to

- **strengthen the innovation** capacity
- **improve a sustainable link** within an industrial textile area and between more industrial areas
- **foster cooperation** on waste management and circular economy

Life M3P
Material Match Making Platform

M3P Platform has been developed thanks to co-funding by the European Life Programme (Life M3P project, LIFE15-ENV_IT_000697)

The on-line Platform: an Overview

The on-line Platform is:

- the “one-stop shop” for industrial symbiosis services with a cross sectoral and cross territoriality scope

The Platform is useful for:

- identification of successful pilot cases between companies offering waste streams and those requiring these as input materials (secondary raw materials)
- new creative concepts for new waste applications

www.lifem3p.eu

M3P PLATFORM

Tool for Industrial Symbiosis to find matches between waste and needed (secondary) raw materials by 5 simple steps

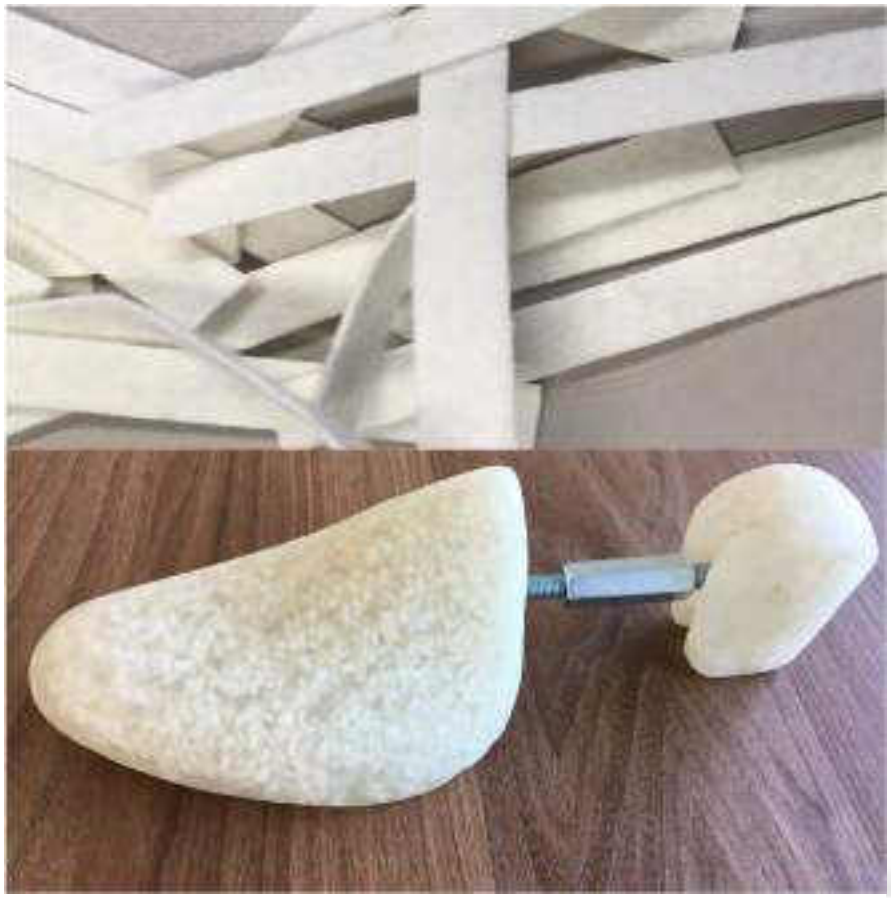
1. Register yourself
2. Register your company
3. Register waste offered by your company
4. Search and look at waste useful for your company
5. Ask for found waste

M3P PLATFORM

Strengths

- Find a company / other sector in which to give your waste
- Increase your profit margins on products
- Eliminate waste disposal and management costs by treating your residue as a by-product
- Control the whole chain of your product
- Respect the environment and ENTeR the network of companies of the Circular Economy

An example



One of the 150 creative concepts:
tensioner for shoe manufactured from trimmings of shoe carriers.

CONCLUSIONS

Industrial symbiosis is a process that can facilitate companies to pursue the circular economy goal, helping the environment and achieving benefits for the society.

The industrial symbiosis is an opportunity :

1. for economy industrial areas and districts;
2. to improve local development;
3. to valorize resources in an aggregative way (scale factor).

M3P Platform is a useful tool for this scope.

High Level Training

Training Path 2: Strategic Agenda & Regional Analysis

Author: Project partner PBN (HU)

PROJECT OBJECTIVES

ENTeR

- Promoting a joint offer of innovative services by the main local R&D centres and business associations/clusters
- Reducing the production of textile waste to prevent the consumption of non-renewable resources
- Fostering the Circular Economy approach and the Industrial Symbiosis
- Supporting the networking between companies through the use of the “Life M3P” platform

PROJECT FOCUS

Focusing on:

- *waste reduction to prevent depletion of non-renewable resources*

→ *Boosting collaboration between textile companies and innovation system to find new green markets for waste and alternative solutions to raw materials*

DEFINITIONS

Strategic Agenda:

- Common vision, set objectives and priorities in long-mid term perspective
- Transnational/regional strategy with relevant stakeholders involvement
- Out of findings coming from the Strategic Agenda, the Action plan has to be delivered

Action Plan:

- Sequence of steps that must be taken
- What will be done (by whom?), when? (time horizon), what specific funds are available (resource allocation)

THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Few facts:

- in Europe around 1.7 million people are employed in 178,000 companies in the textile and clothing industry
- It covers the entire textile value chain and wide range of activities (the production of woven, knitted or non-woven fabrics, the treatment of textile materials (finishing, dyeing, coating)
- The retail and B2B sector is also an important part
- Biggest producers: France, UK, Italy, Spain and Germany (together they produce around three quarter of EU production)

THE EUROPEAN TEXTILE AND CLOTHING INDUSTRY

Competitiveness of this industry:

- During the last decade, the sector has undergone a strong diversification process (due to a combination of technological changes, increase of production costs etc.)
- Globalisation and technological progress has caused a rethinking process

For the coming years the most important 4 innovation topics:

1. Smart, high-performance materials
2. Advanced digitised manufacturing, value chains and business models
3. Circular economy and resource efficiency
4. High value added solutions for attractive growth markets

THE EUROPEAN TEXTILE RECYCLING SECTOR

- Textile production accounts for 10% of the world's carbon emissions, is reportedly the second most polluting sector in the world and represents a complex, problematic waste stream

- Textile industry is all about transforming resources (materials, energy, water, chemicals) into value added products for business or private usage

- The end user and costumer behaviour has changed over the years

LEGISLATION AND POLICY FRAMEWORK, EU ACTIONS

The central concern of waste policy is to avoid and recycle waste.

- Requires technical, social and political framework, and also legal decisions.
- Regulations are directly applicable in the Member states, derives must be implemented into national law
- <u>A few example</u>:

-**The European Waste Framework Directive (Directive 2008/98/EC):** it defines essential waste-related terms and defines among other things, a five-stage waste hierarchy

-**Directive 2008/98/EC**: sets the basic concepts and definitions related to waste management (definitions of waste, recycling and recovery)

-**Regulation (EC) No. 1013/2006 of the European Parliament and of the Council:** it defines which conditions waste can be shipped between countries

-**Decision 2000/532/EC:** establishing a list of wastes

-**May 22. 2018**: new EU Circular Economy Package: the aim is to promote circular economy, waste prevention and recycling Europe-wide

There are three options regarding the waste management for used textiles and worn clothing:

1. They become part of the residential waste and are collected in bins for residual waste
2. Larger quantities are collected and handled centralized in recycling centres operated by municipalities/city administrators or county governments. This is free of charge! for registered citizens, but companies have to pay a certain fee
3. Further collection of used textiles and worn clothing is organised by private companies or charity organisations (e.g. Red Cross or Worker's Samaritan Organization)

TEXTILE WASTE FROM END-OF-LIFE CLOTHING

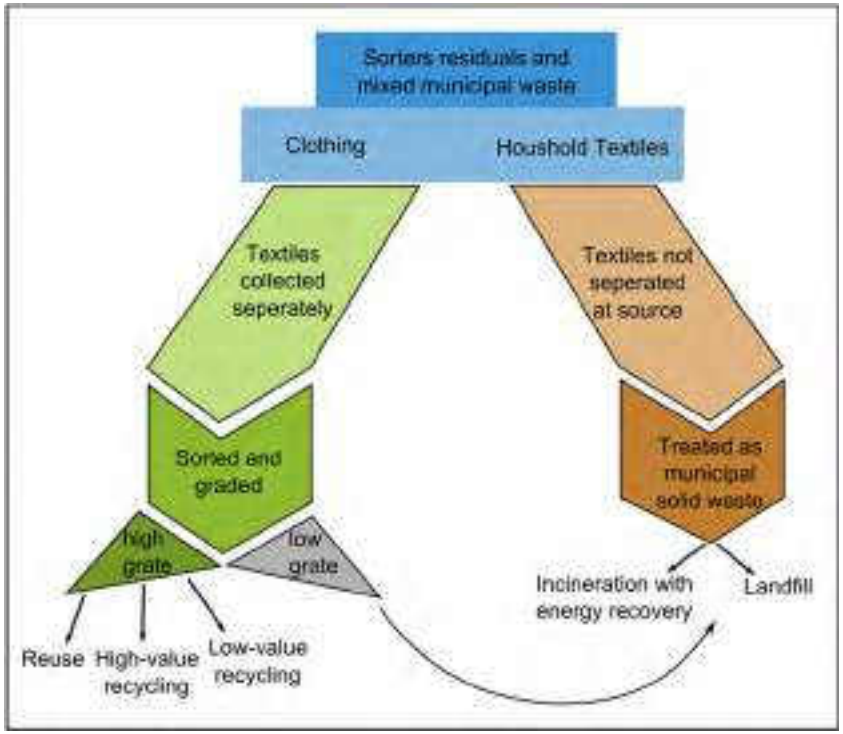
Sorting:

The sorting of the collected goods determines which recycling path a garment goes through. The more accurate the sorting is tailored to the customer's needs, the more goods can be used for high-quality recycling, ideally for reuse as second-hand goods.

Treatment:

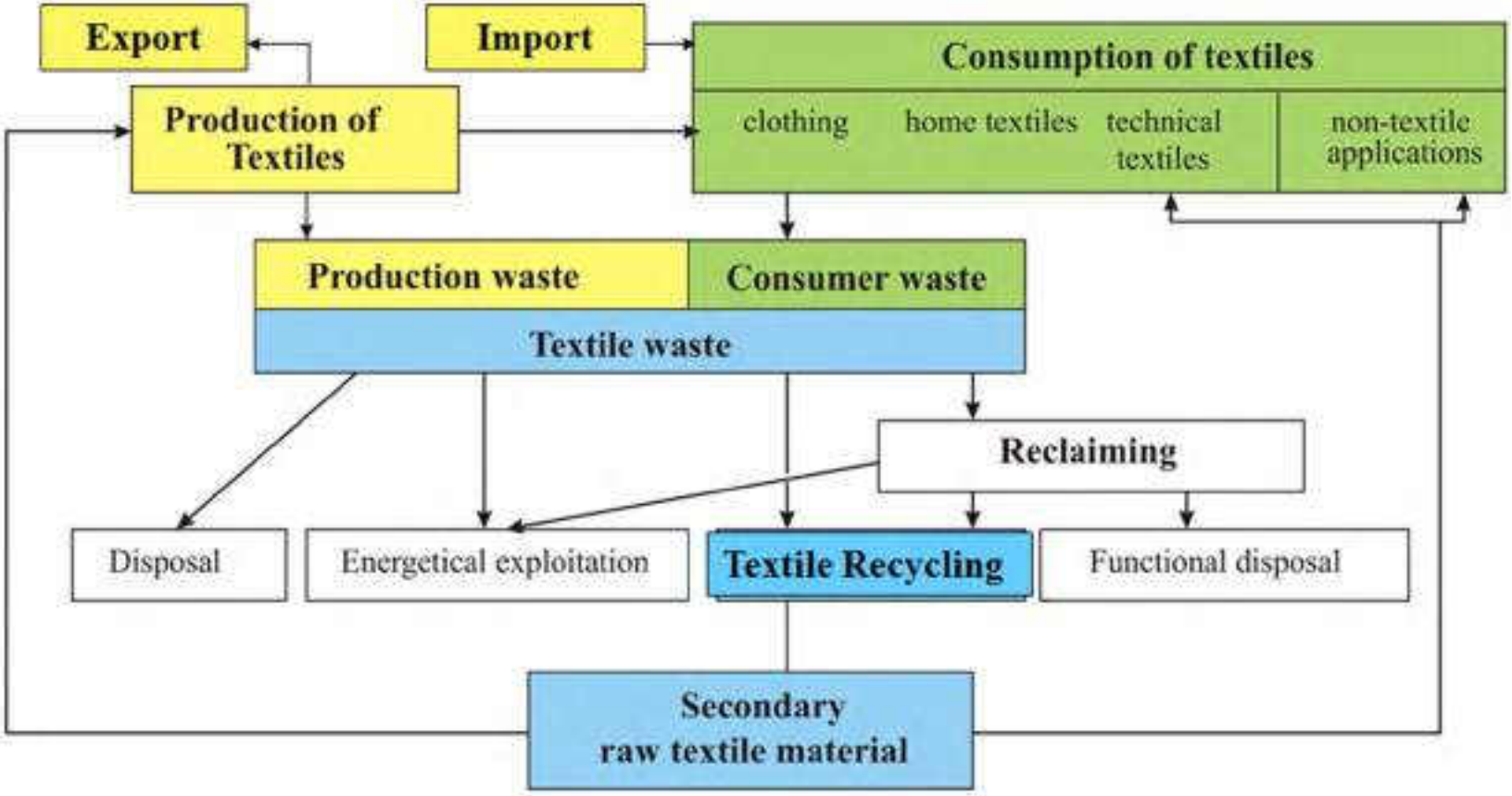
Clothing and household textiles are complex materials due to the variation in their composition, their quality at the point of disposal.

Several companies have problems in storing their textile production waste due not enough storage space.



Flow diagram of end-of-life clothes and household textiles from source to treatment

WASTE TREATMENT AND RECYCLING



Material cycles for textile waste

EURATEX

EURATEX: is the European Apparel and Textile Confederation representing the interest of the European textile and clothing industry at the level of EU institutions.

The following research priorities are identified:

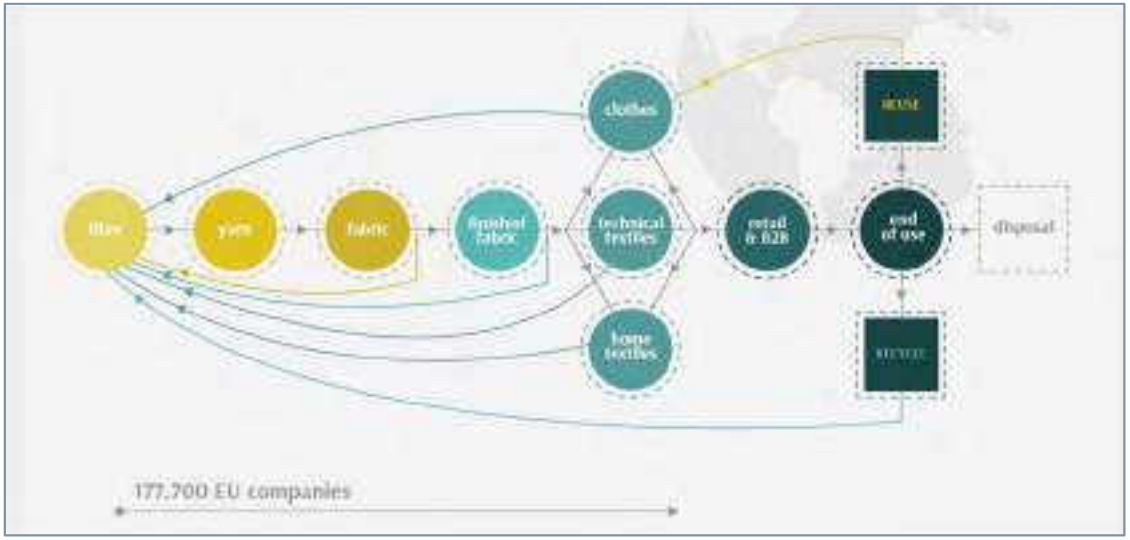
1. Novel flexible process technologies to save water, energy and chemicals
2. High-tech textile recycling for circular economy concepts
3. Sustainable substitutes for hazardous or restricted textile processing and chemicals and bio-chemistry based textile processing
4. Bio-refinery concepts utilising European agricultural and forestry resources, waste or by-products for textile fibres and developing their processing and application aspects
5. Greater use of EU-origin natural fibres and improving their processing and application aspects

CIRCULAR ECONOMY AND RESOURCE EFFICIENCY

Circular Economy is a production and consumption model which involves reusing, repairing, refurbishing and recycling existing materials and products to keep materials within the economy wherever possible.

“The Circular Economy” is rapidly becoming one of the most used terms in the European textile and clothing industry.

Prospering in the Circular Economy will truly be achieved by bringing together the existing private and public initiatives, removing barriers, investing to foster technological innovation and stimulating the demand.



Circular economy approach in textile and clothing manufacturing

OBJECTIVES OF THE STRATEGIC AGENDA

- Analyses the current technical and regulatory context valid in the participating regions.
- Is based on data and studies coming from the Regional analysis. It links and drives the Circular Economy considerations and strategic actions.
- Describes waste management strategies and action lines
- Defines the strategy to address the waste management, objectives, and concrete actions to be developed
- Derives objectives to foster the textile industry in the partner regions towards the Circular Economy.
- Acts as guideline to foster innovation on waste management and resource efficiency in the partner regions and to push the collaboration between partners and others actors/stakeholders from authorities, industry and R&D.
- Can be used as guideline for other regions that are faced with the same problems and topics.

METHODOLOGY

The Strategic Agenda of ENTeR is jointly defined on the basis of problems which are relevant for the participating regions. It provides a common vision and sets objectives and priorities in a mid- to long-term perspective.

It was done in two phases: desk phase and field phase

Desk phase: the state of the art of textile waste management and recycling in each partner region (Italy – Lombardy, Germany – Saxony, Poland – Lodzkie Region, Check Republic, and Hungary) was studied and summarized in specific regional reports. The regional reports show the legal, social and technical aspects concerning textile waste management.

Field phase: relevant stakeholders in the individual regions were interviewed. Questionnaires on the current situation of textile waste management were prepared and distributed among companies and industrial partners in the textile branch.

Based on these data the Strategic Agenda was prepared.

SUMMARY OF REGIONAL ANALYSIS

6.1. Summary of Regional Analysis Czech Republic

Number of interviews/ questionnaires: 22	
Findings:	
At the moment: • municipal waste management system available - textile waste is not sorted and disposed with other municipal waste • collection of textiles and outworn clothing organised by private companies/charities • collected textiles sorted according to quality and offered for further use (charity), sold in second-hand shops, forwarded to third world countries, recycled and the unusable share disposed • textiles which cannot be redistributed or recycled are usually used for energy recovery or disposed to landfills • textile recycling is operated on the private commercial basis • companies already reuse their textile waste internally • companies look individually for external business partners	
Technology: • mechanical processing like cutting and tearing • obtained textile material is usually used for manufacturing of nonwovens or for production of cleaning materials, various fillings, insulation material, parts for automotive industry etc.	
Challenges: • lack of opportunities for reuse of waste coming from technical textiles caused especially by the technical character of such textiles (heavy coated or laminated, composites with latex, paper etc.)	
SWOT analysis:	
Strengths: • regular waste generation • sorting • large quantities of waste • mono-fraction or valuable waste	**Weaknesses:** • long distances to the recycling company • poor quality of waste • low quantities of waste
Opportunities: • re-use of textile waste in new products • offering waste via a recycling exchange platform • internal recycling • investments in new technologies, R&D activities	**Threats:** • the required investments needed for solving • lack of market for recycled products • contamination of textile waste with chemicals

SUMMARY OF REGIONAL ANALYSIS

6.2. Summary of Regional Analysis Hungary

Number of interviews / questionnaires: 26	
Findings:	
At the moment: • Hungarian companies are looking for solutions to recycle their textile waste as much as possible • no separated collection of textiles waste and communal waste: it is handled and transferred as a communal waste - without separation and selection • most common way the companies handle their waste is send it to disposal in landfills or to incineration • issue of textile waste management system and recycling is very urgent	
Technology: • textile waste recycling technologies are available in Hungary but only in a small range • mechanical processing as tearing and cutting (Temaforg, TESA) • the obtained textile material is usually used for manufacturing of non-woven textiles or for production of cleaning materials, various fillings, upholster materials, insulations, geotextiles • this solution is mostly available only for "simple" textile waste without any heavy chemical treatment (coating, laminating)	
Challenges: • need of new technologies related to textile & clothing sector and complicated textile waste • improvement of waste collection and sorting	
SWOT analysis:	
Strengths: • regular waste generation • with large quantities of waste	**Weaknesses:** • no relevant recycling company in the region • no regional waste management system available • lack of recycling knowledge • lack of capital for investment • long distances to the recycling company to find a recycling possibility is very difficult • poor quality and small quantities of the waste • lack of waste utilization possibilities
Opportunities: • offering waste via a recycling exchange platform, together with business partner • search not only in regional but also in interregional level.	**Threats:** • required investments needed for problem solving • lack of market for recycled products • high processing costs

SUMMARY OF REGIONAL ANALYSIS

6.3. Summary of Regional Analysis Italy

Number of interviews/ questionnaires: 13
Findings:
At the moment: • textile companies are increasingly oriented towards environmental • subjects: sustainability, circular economy and new materials • the waste production coming from provincial textile sector for 2016 is about 19.510 tonnes/year, where 87.7% of derives from textile industry, while 12.3% from production processes of clothing and articles in leather and fur • large quantities of liquids deriving from tanning activities, such as sludge coming from on-site treatment of effluents and tanned leather (scraps, waste, scraps, polishing powders), containing chromium
Technology:
Challenges: • increase the market acceptance for recycled products (social/cultural barrier) • overcome the lack of technological know-how • decrease in bureaucracy and simplification in administration • establishment of recycling plants for the strongest sectors on the territory
SWOT analysis:

Strengths:	Weaknesses:
• well-established sector in the Lombardy region both in terms of number of companies and employees, as well as growing in annual turnover (+ 2.4%); in 2017 the sector generated roughly 13 billions € in export (+).6% with respect to 2016, source ISTAT); • presence of associative and industrial product groups that lead companies to a more sustainable production (Confindustria); • constant support and continuous involvement of public administrations and stakeholders to lead and encourage environmental sustainability in the textile sector; • interest of companies on environmental issues also due to the request by customers of products with a reduced environmental impact or	• high number of disconnected SMEs with individually quantities of waste too small for a continuous supply for new recycling possibilities; • negative dynamics of domestic demand, in terms of business-to-business and sell-out demand; • staff often poorly prepared (insufficient academic preparation) on environmental issues or lack of personnel dedicated to sustainability; • reduced availability of investments for research of green alternatives in production; • difficult interpretation of legislation on circulation of waste destined for recycling.

deriving from recycling processes; • quick response and flexibility of processes and products, achieved through new and innovating technologies.	
Opportunities: • development of projects for the involvement of companies in this sector; • dialogue between Public Administrations and stakeholders and other actors in the sector to identify needs and to break down the barriers that hinder the transition to a circular economy and recycling of materials; • involvement of design schools and start-up companies for the development of new materials or technologies aimed at reducing the environmental footprint of the textile supply chain; • implementation of specific university courses on LCA (through development of specific software) for the promotion of transition from Linear Economy to Circular Economy; • development of specialized databases and exchange platforms for information, materials and technologies; • approach to PEF (Product Environmental Footprint) methodology; • financial contribution issued by the UE and Piano Nazionale Industria 4.0.	Threats: • purchasing policies based only on product cost without considering environmental costs; • textile trends, such as: fast fashion, low cost products; • low competitiveness with foreign production (mainly Far East); • customers' cultural barriers in accepting products deriving from recycling chain; • regulatory barriers, administrative immobilization in the implementation of new European provisions within the Circular Economy; • many competitors operate in contexts with fewer environmental restrictions.

SUMMARY OF REGIONAL ANALYSIS

6.4. Summary of Regional Analysis Poland

Number of interviews/ questionnaires: 13
Findings:
At the moment: • textile waste recycling in Poland is complex and expensive • technologies for textile recycling are very expensive • high effort in registration and processing (separation, storage, logistics) • lack of available technological or technical solutions • textile recycling is economically not attractive • no structural support of the government, possibilities of financial support from EU or national funds • companies, which achieved significant progress in the field of textile • waste management, made it with their own financial resources
Technology: • technologies that allow textile waste management in 100% are very expensive • lack of available technological or technical solutions and too much effort in registration and processing (separation, storage, logistics)
Challenges: • continued growth of the textile waste stream is not in correlation with the development of the collection system and the construction of installations for textile waste processing • problem with textile waste management in Poland remains still unresolved • problem of textile waste in Poland is global and requires substantial funds and regulation • urgent need of finding recycling possibilities
SWOT analysis:

Strengths:	Weaknesses:
• initiatives are taken to prevent waste generation. • one of the basic activities in waste prevention is raising the environmental awareness of the Region's inhabitants through educational campaigns • the strong point of the region is its location in the central part of Poland, and the biggest advantage is location in the transit and transport node. • strong road infrastructure has a major impact on other industry sectors, including improvement of waste management rationalization	• insufficient infrastructure serving integrated waste management. • inadequate number of installations for processing municipal waste • a large number of landfills that have not yet been reclaimed but are excluded from use and low efficiency of selective municipal waste collection

SUMMARY OF REGIONAL ANALYSIS

6.5. Summary of Regional Analysis Saxony

Number of interviews/ questionnaires: 15

Findings:

At the moment:

- In Germany, 1.5 to 1.9 million tonnes of textile waste (old textiles and textile production waste) are produced each year
- well-organised clothing collection system → large part of textile waste can be reused
- technological solutions to treat conventional textile waste are sufficiently available and state-of-the-art.
- nevertheless 300,000 tonnes of textile waste are incinerated or sent to landfills
- volume of textile waste continues to grow
- transition from clothing textiles to technical textiles → smart textiles with electronics, high-performance textiles with special coatings or finishes, composite materials, etc.

Technology:

- waste from textile production and the clothing industry can be processed very well with tearing, cutting, carding, processing of individual fibres, re-use in nonwovens, insulation materials, automotive industry, etc.

Challenges:

- structural changes of the national and regional T&C sector from the classical production towards the production of technical textiles are ongoing
- textile waste is changing concerning the kinds of raw materials (high performance fibres), the composition of textile fabrics, the surface quality (functional coatings), use of electronic parts in smart textiles, etc.
- recycling industry is not in a position to successfully process waste from technical textiles (such as composites, textile-based components, smart textiles) using the current state of the art technologies
- new methods/approaches to treat novel materials are required increase of n
- new materials lead to a great variety of types of waste with small amounts of waste. Important is to channel the waste streams and build up networks for waste management at interregional level (for instance via a database)

SWOT analysis:

Strengths:	Weaknesses:
• varietal purity of textile waste • separated waste collection (sorting) • high amounts of waste available • regular volume available • textile waste is valuable (intrinsic value) • short distances to disposal companies	• non-defined waste • only small amounts are available • no regular volume available • poor quality waste • long distances to the recycling company

Opportunities:	Threats:
• reutilization of waste in the own company (production cycle) • reutilization in new products (own or other company • offering waste via a recycling platform • investment in novel technologies / applying of funding • activities in research and development (R&D)	• high expenses for treatment and re-processing • investments to solve the waste problems required (additional costs) • missing market acceptance for recycled products • waste is contaminated (polluted), reutilization is not possible • legal rules / guidelines (for instance REACH or special certificates)

DISCUSSION OF THE RESULTS

Technological solutions to treat conventional textile waste are sufficiently available and state-of-the art for Germany and Check Republic. For Hungary and Poland there is still a lack of technological solutions and also the availability for a wide range of companies in the textile sector is not given.

Summarizing the results of the interviews, questionnaires and SWOT-analysis of the partner regions, the following future fields and trends in terms of textile waste management and recycling with relevance for the European (Central Europe) textile industry can be identified:

- increasing the degree of recycling through state-of-the-art processes,
- closing material cycles,
- conversion to environmentally friendly production techniques and the use of recyclable materials,
- designing in line with recycling requirements (Eco-design),
- the promotion of textile-based composites and
- the IT-based reduction of waste.

In Central Europe a textile value chain capable of recycling fabrics, regenerating fibres and maximising resources in production is already existing but not established in a high advanced level for all regions and countries

High Level Training

Training Path 3: Main textile recycling technologies and methods to recover, reuse and recycle textile waste

Author: Project partner STFI (DE)

CONTENT OF TRAINING PATH 3

Introduction

Definition of terms related to textile recycling

Textile waste - materials cycle

Processing of textile waste

a) Mechanical
b) Physical
c) Chemical

Recycling of special waste - Carbon fibres

Textile waste from end-of life clothing

Conclusions

INTRODUCTION

Nowadays, a sustainable textile recycling can be seen as a global challenge since the economy needs a continuous supply with raw material at any time. On the other hand natural limits are given to the world-wide consumption of resources. The utilization and recycling of waste is becoming even more important due to the shortage of virgin materials and strong concerns of a non-sustainable use of natural resources. Furthermore, the increasing costs of waste management and limited landfill capacities have also increased the interest in recovering waste as material or energy.

This training module on recycling technologies and how to recover, reuse or recycle textile waste should help to deepen the knowledge about such recycling processes and methods to raise the awareness of textile companies, to motivate their active cooperation and to improve know-how and experience in recovering or recycling textile waste.

DEFINITION OF TERMS RELATED TO TEXTILE RECYCLING

Closed Loop: Aim is to redirect the raw materials contained in the products after their exploitation in the resource cycle for the production of new products.

Cradle-to-Cradle: System to manufacture products by keeping the materials in a close cycle. Already the raw materials should be produced in such way that makes feasible their later re-use.

Downcycling: Products are supplied to a recycling process. The result of the recycling are new products which are lower in their quality and value than the initial product.

Open loop: Another product with a different application is produced from the material or parts of an end-of-life product.

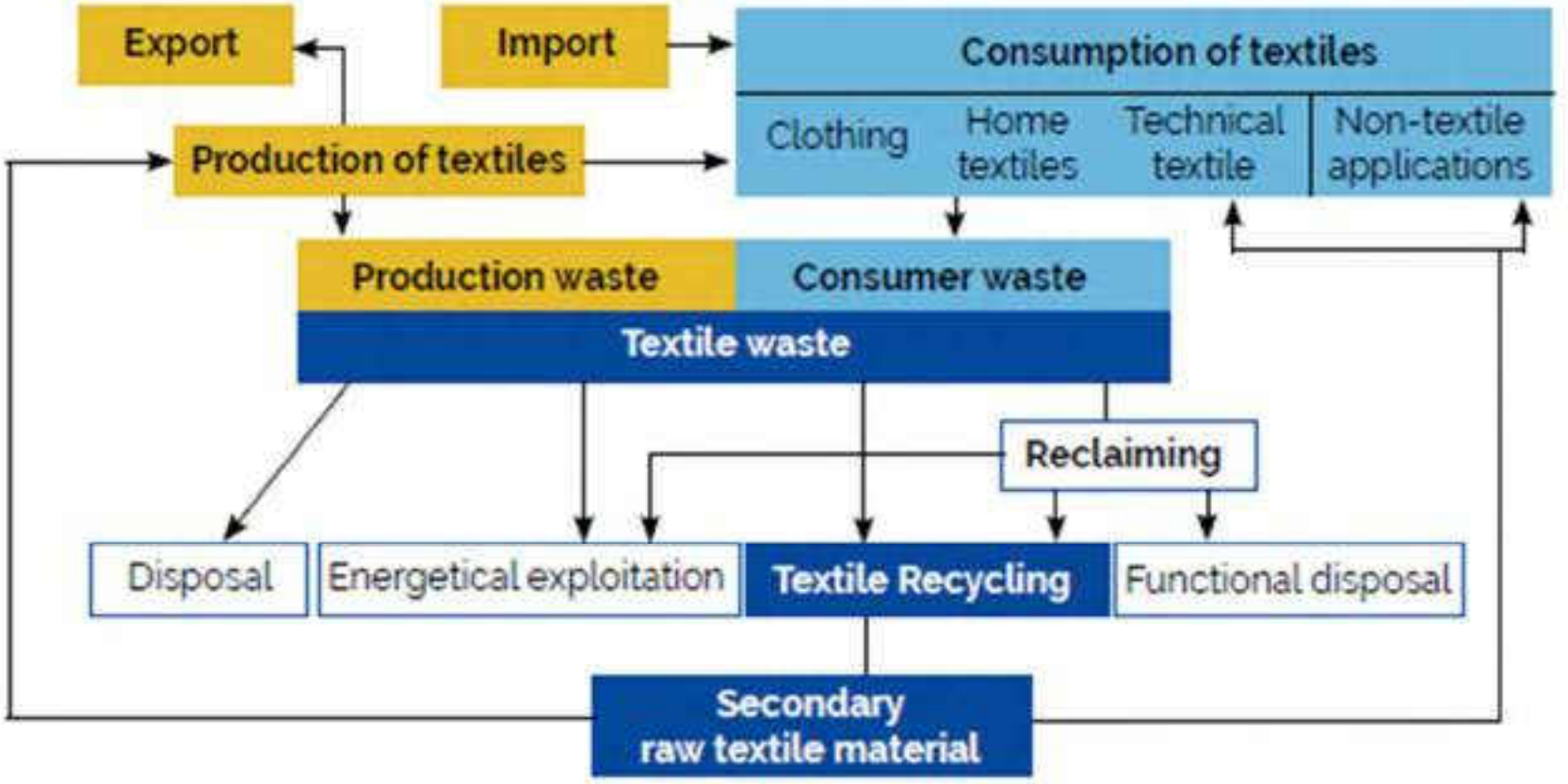
Primary raw material: Natural raw materials are extracted from nature or mainly produced from natural raw materials.

Recovery: is the regaining or returning of waste material by processing in ways other than being destroyed.

DEFINITION OF TERMS RELATED TO TEXTILE RECYCLING

Recycling/reuse: are the frequently used methods of waste disposal and means giving waste a second life.
Secondary raw material: is raw material regained by recycling and used as raw material for new products.
Upcycling: The aim is to completely reuse the original components of used cloths or shoes and to produce an equivalent recycling product, for instance to manufacture from shoes waste shoes again.
Textile waste: as raw material for textile recycling is divided into production waste and used textiles (consumer waste).
Textile production waste: is coming from the manufacturing of all kinds of textile products.
Used clothing/textiles: comprise all worn clothing but also all other used textile goods from home and household (curtains, bed linen, towels…)

TEXTILE WASTE – MATERIALS CYCLE



(**Source:** STFI)

TEXTILE WASTE - MATERIALS CYCLE

- **Textile waste** is coming from the production of textile goods (**production waste**) and from the consumption of textiles (clothing, home and household textiles) as so called **consumer waste**.
- Favourite option is to **re-utilize** the waste material by returning it directly into the production process to save raw material.
- If not possible, the textile waste has to be **recycled** by mechanical, physical or chemical recycling to get secondary raw materials which can be used as raw material for new products.
- If no re-utilization, no recycling or functional disposal (secondary use by another application) can be done, then a **thermal/energetic exploitation** is applied in public incineration plants.
- Finally, if no other option is possible, the waste has to be **disposed in landfills**.
- **Used clothing** is collected and redistributed by charity organizations to socially needy people. Low-quality clothing is often exported to the third world countries or for recycling.

TEXTILE WASTE - TYPES OF WASTE

Textile production waste material: fibre waste (also including dust and fluff), yarn residues, textile fabrics, pieces of textile fabrics (selvedges), cutting waste, defective products, fibres





Textile consumer waste: worn clothing but also all other used textile goods from home and household (curtains, bed linen, towels…)





(**Source:** STFI)

PROCESSING OF TEXTILE WASTE – MECHANICAL RECYCLING

Processing

The traditional method for the recycling of textile waste is the use of cutting and tearing processes to obtain reclaimed fibres. Fibre/thread opening is carried out by breaking the textile structure through cutting, shredding and tearing to produce reclaimed fibres. By mechanical processes, such as carding, a web formation can follow subsequently.

Use of reclaimed fibers

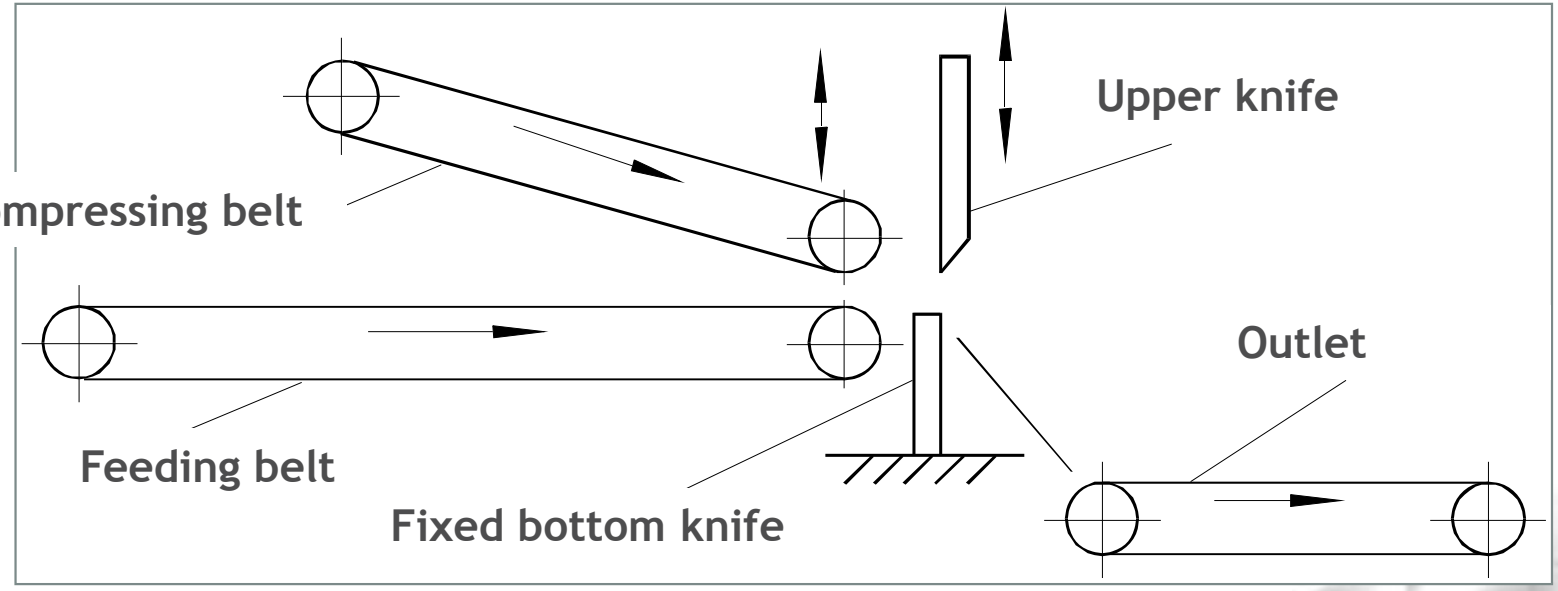
The material obtained is mostly used for manufacturing of fibre nonwovens (needle-punched or stitch-bonded nonwovens) or for the production of cleaning rags, filling material, insulation material, geotextiles, upholstery and automotive textiles which means a secondary use of waste.

PROCESSING OF TEXTILE WASTE – TEARING PROCESS PRINCIPLE

Cutting machine

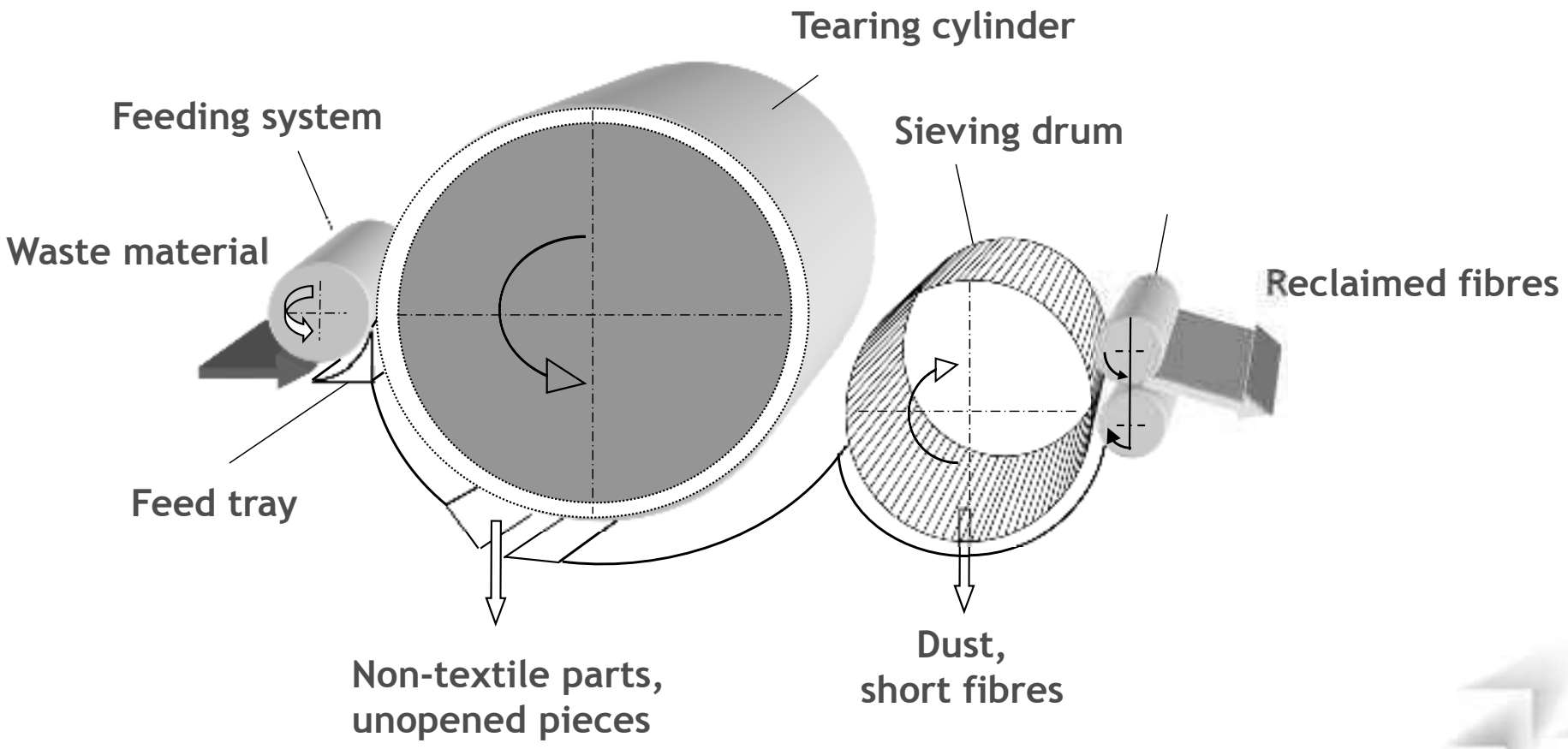
First step:
Cutting the waste material into pieces

Guillotine-like principle



PROCESSING OF TEXTILE WASTE – TEARING PROCESS PRINCIPLE

Second step:
Processing textile waste into fibres



PROCESSING OF TEXTILE WASTE – TEARING PROCESS PRINCIPLE

Second step:
Processing textile waste into fibres

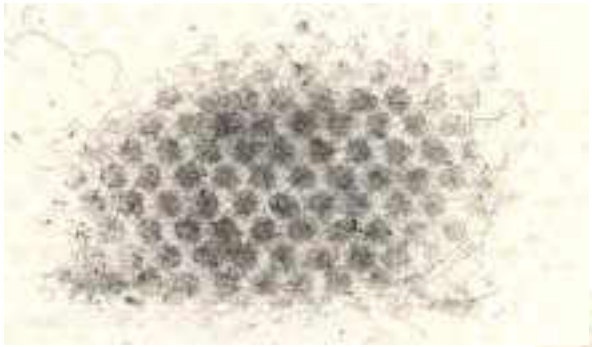
Lab-scale tearing machine

Pin-coated tearing cylinder

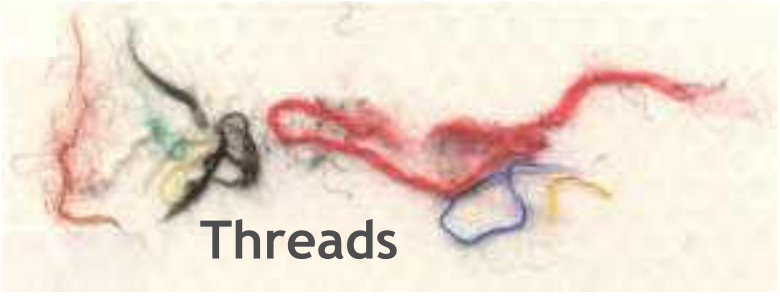
(Source: STFI)

PROCESSING OF TEXTILE WASTE – TEARING PROCESS RESULT


Neps



Fibre dust, short fibres


Threads

Reclaimed fibres as a blend of:


Unopened pieces


Fibres with different lengths

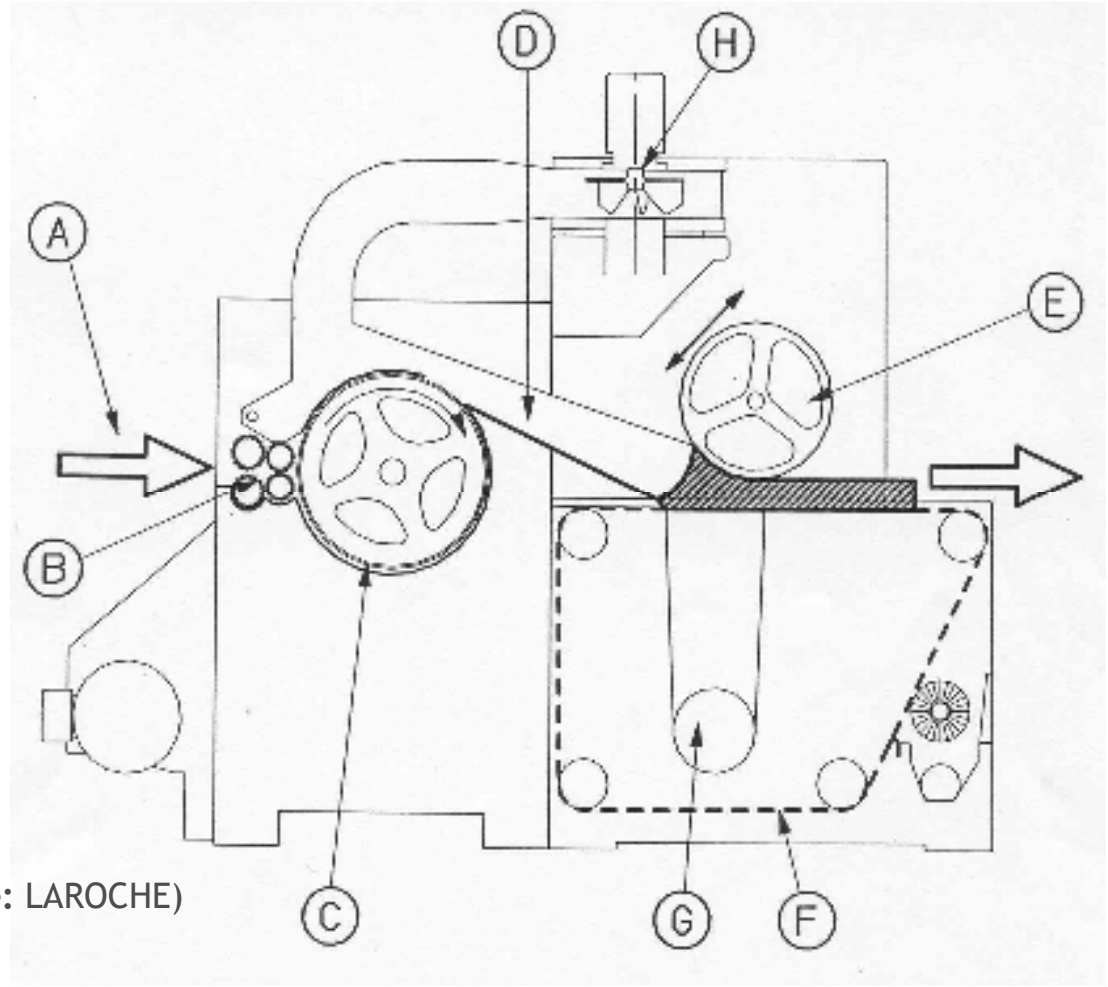
(Source: STFI)

PROCESSING OF TEXTILE WASTE – RECLAIMED FIBRES

Use of reclaimed fibres in	Required fibre quality				
	Type of Polymer	Fineness	Strength	Length	Colour
Reinforcement (Concrete)	X		X	X	
Protection against Erosion	X				X
Geotextiles	X	X	X	X	
Upholstery	X	X (Crimp)		X	
Wipes	X	X		X	

PROCESSING OF TEXTILE WASTE – RECLAIMED FIBRES

Raindom laid web – principle of system matformer (Fa. Laroche/F)

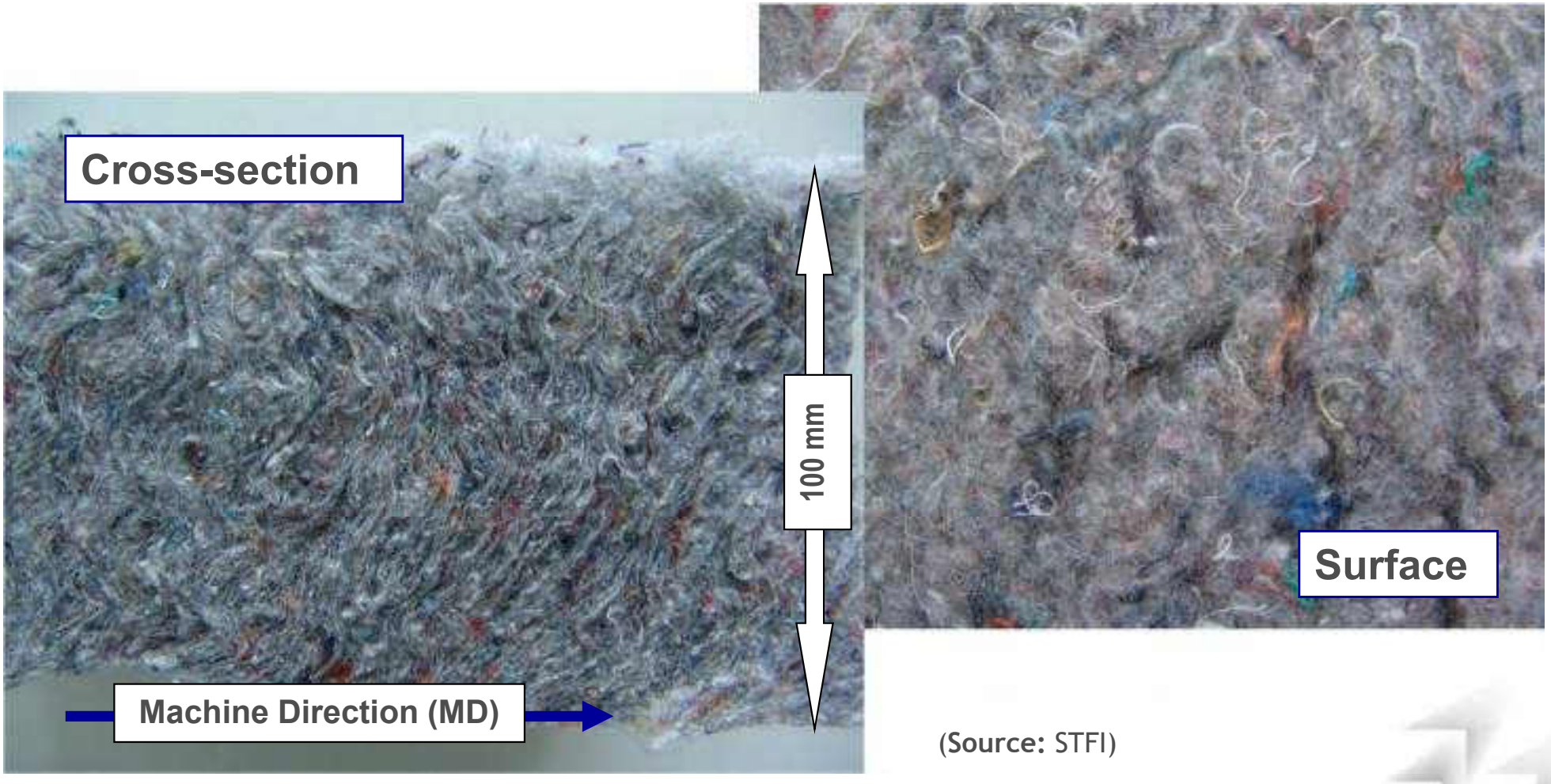


(**Source:** LAROCHE)

A Fibre fluff
B Material feed
C Opening roller
D Air channel
E Pressure roller
F Sieving conveyor
G Intake suction
H Additional air

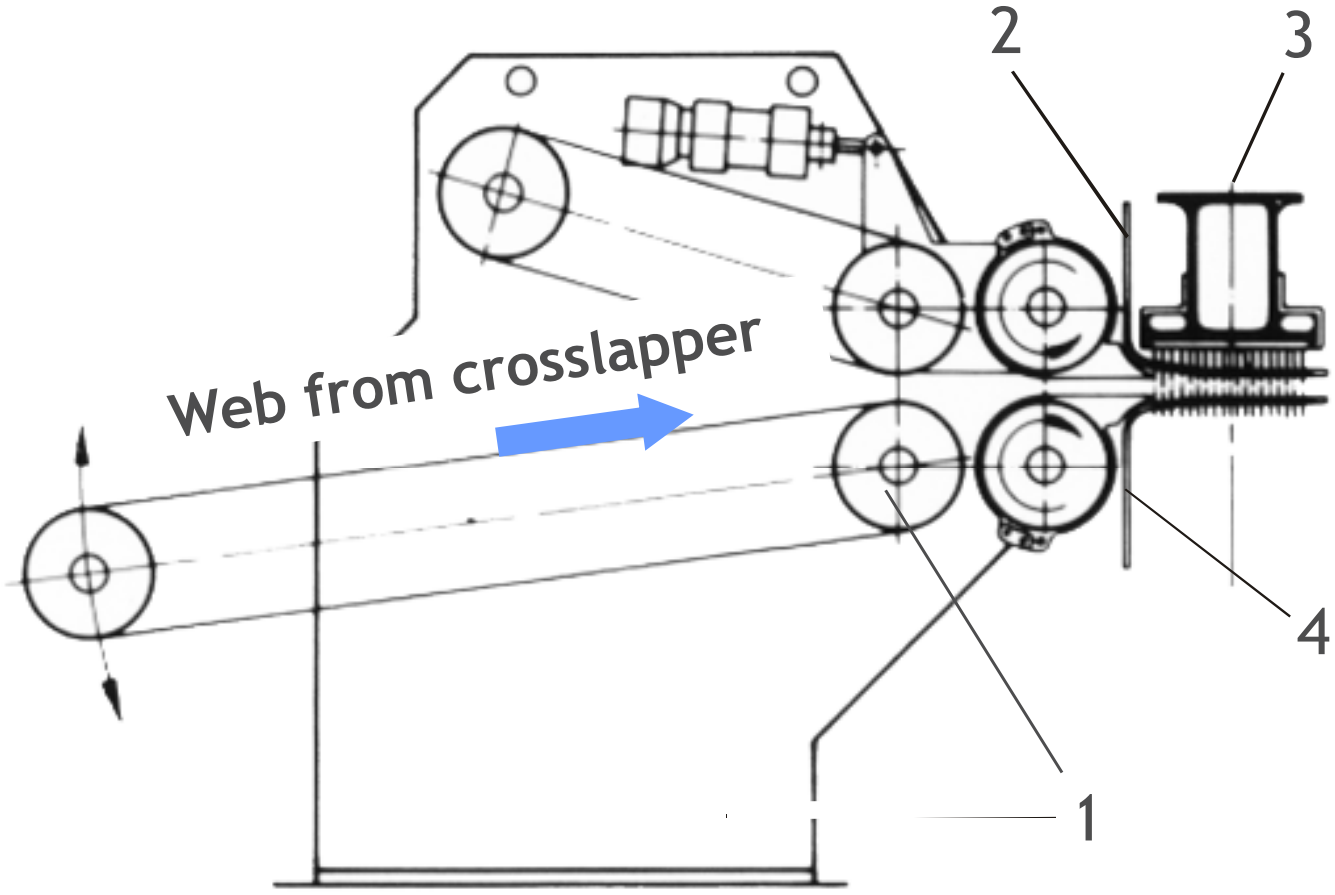
LAROCHE

Raindom laid nonwoven structure after thermal bonding



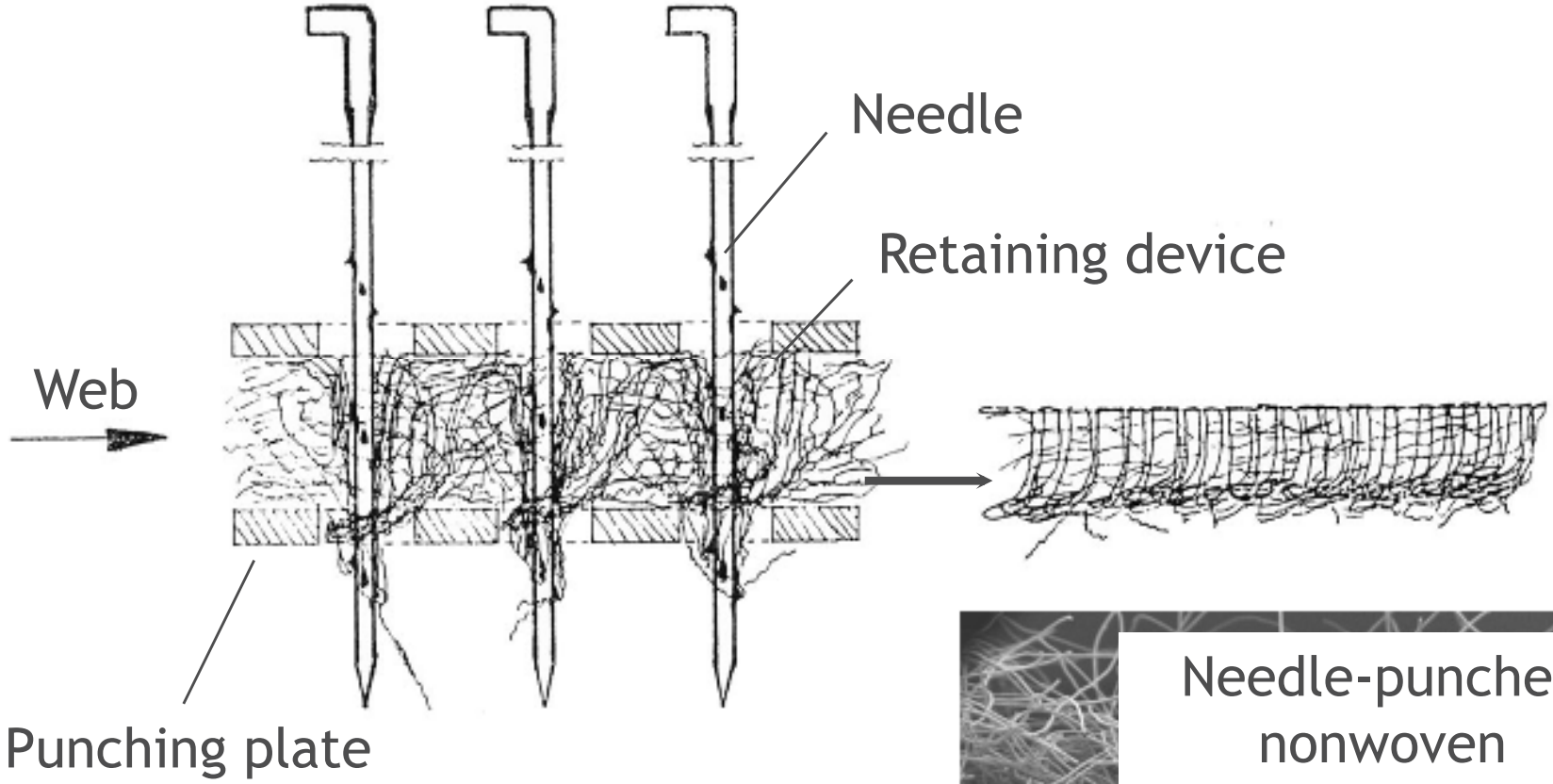
(Source: STFI)

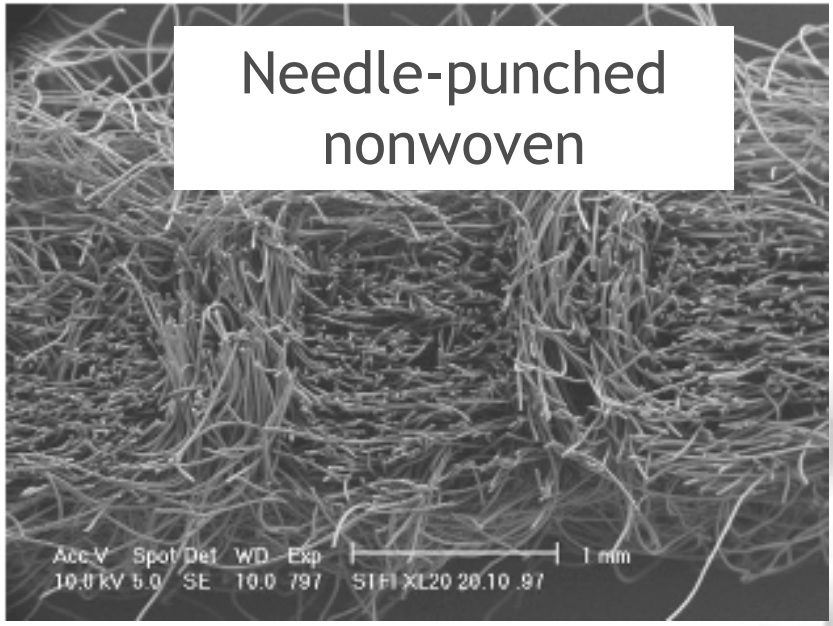
Web bonding by needle-punching (principle)



1 Feeding system
2 Retaining device
3 Needle board
4 Punching plate

PROCESSING OF TEXTILE WASTE – PROCESSING OF RECLAIMED FIBRES





Needle-punching
Fibre orientation and entanglement

(**Source:** STFI)

PROCESSING OF TEXTILE WASTE - MECHANICAL RECYCLING MACHINERY (EXAMPLES)

- Modern technology/equipment for processing of nearly all kinds of textile waste is available
- Quantity specialised or product specialised plant line concepts
- Random web forming as cost-effective processing technology/concept
- Other web bonding through needle-punching process
- Machinery manufactured in Europe is available for the world markets

PROCESSING OF TEXTILE WASTE - MECHANICAL RECYCLING: MACHINERY (EXAMPLES)

Cutting of textile waste

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

(Source: PIERRET)

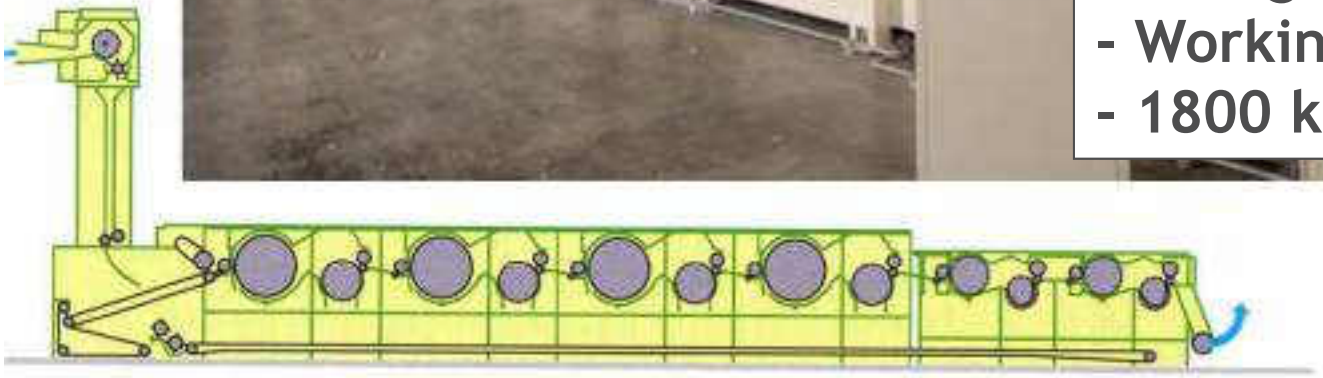
PIERRET INDUSTRIES S.P.R.L., Corbion/Belgium

PROCESSING OF TEXTILE WASTE - MECHANICAL RECYCLING: MACHINERY (EXAMPLES)

Tearing line - processing of production waste

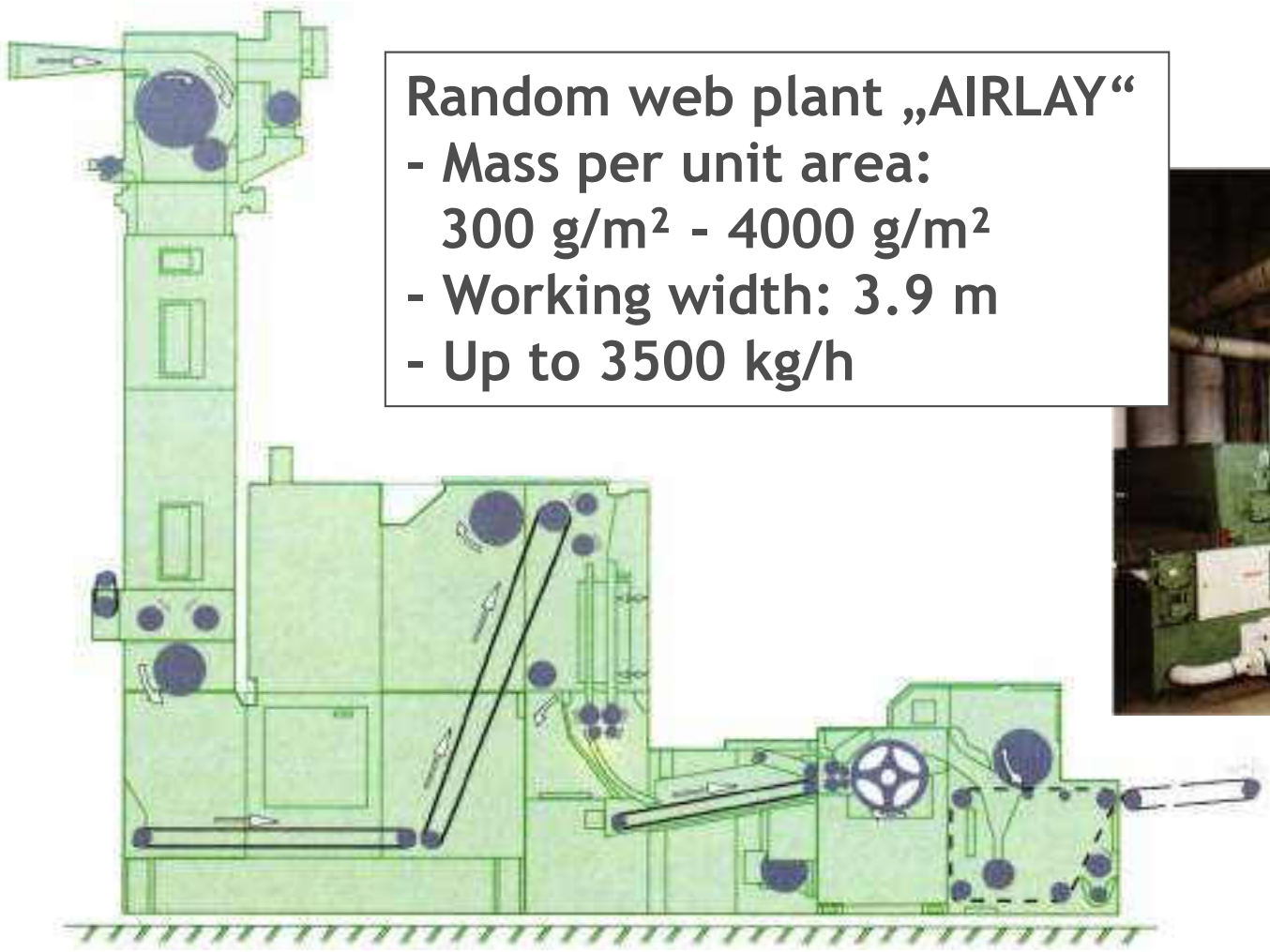
(Source: LAROCHE)

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



LAROCHE S.A., Cours La Ville/France

PROCESSING OF TEXTILE WASTE - MECHANICAL RECYCLING: MACHINERY (EXAMPLES)



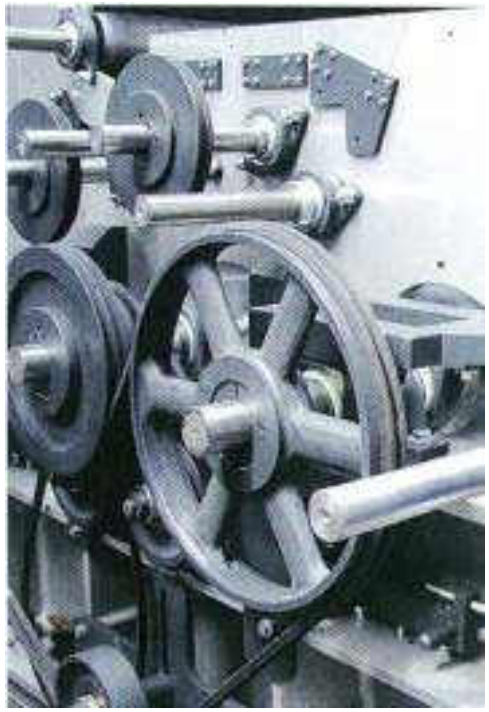
Random web plant „AIRLAY“
- Mass per unit area:
  300 g/m² - 4000 g/m²
- Working width: 3.9 m
- Up to 3500 kg/h

(**Source:** LAROCHE)

Processing of reclaimed fibres

LAROCHE S.A., Cours La Ville/France

PROCESSING OF TEXTILE WASTE – MECHANICAL RECYCLING: MACHINERY (EXAMPLES)



(**Source:** STFI)

Web bonding by needle-punching

(**Source:** DILO)

PROCESSING OF TEXTILE WASTE – PHYSICAL RECYCLING - EXTRUSION

Processing

- Physical recycling is feasible for thermoplastic materials and the waste is re-granulated and can be used as raw material again.
- Extrusion of polyolefins, polyester, and others in the form of various plastic products and textile materials are processes which involve the melting, shredding or granulation of thermoplastic waste.
- The primary criterion for this mechanical recycling (melt processing) is the purity of the end product. Therefore, the waste must be sorted prior to recycling.
- Sorting of plastics can be carried out by hand or machine according to colour and chemical structure of the plastics. Nowadays mainly automatic sorting is used.
- After sorting, the thermoplastic waste is melted down directly and moulded into a new shape, or melted down after being shredded into flakes and then processed into regranulates.

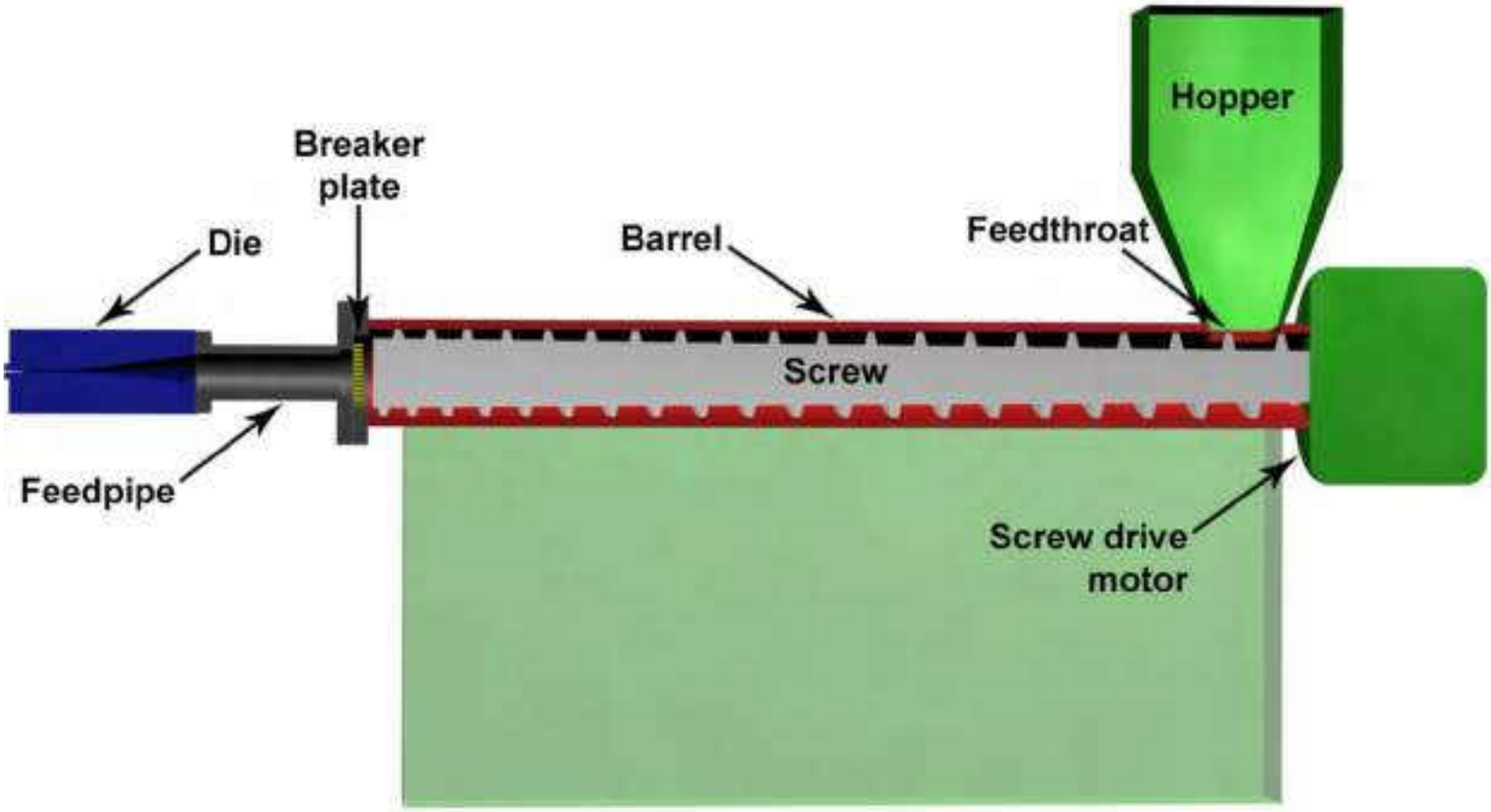
PROCESSING OF TEXTILE WASTE – PHYSICAL RECYCLING - EXTRUSION

Reprocessed material

- A main problem in the physical recycling (re-melting) of thermoplastic material is that reprocessing gives a heat impact to the material causing a change/reduction of properties and makes a re-use for the same application difficult.
- Effects of recycling processes on physical, mechanical and degradation properties can be decreased tensile properties, changed thermal characteristics, photo-sensitivity or a worse degradation behaviour.

Extrusion unit at STFI's spunbond lab
(Source: STFI)

PROCESSING OF TEXTILE WASTE – PHYSICAL RECYCLING - EXTRUSION



Extrusion process (Source: Wikipedia)

PROCESSING OF TEXTILE WASTE – CHEMICAL RECYCLING

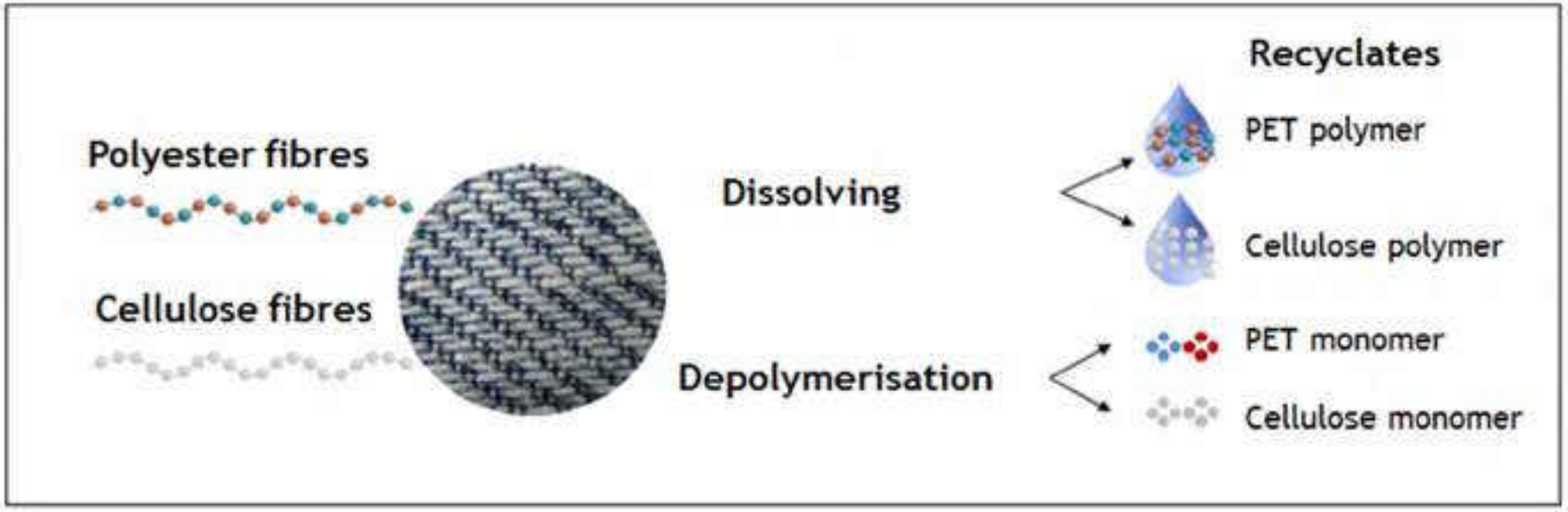
Processing

- Chemical recycling is the production of chemical products from waste polymeric materials by economically feasible processing.
- It includes depolymerisation into monomers with a purity level suitable for re-polymerization of material but also dissolving with suitable solvents while maintaining the polymer character.
- Other methods for chemical recycling are pyrolysis (depolymerisation by means of selected parameters, use of catalysts and heat) or targeted depolymerisation processes (like hydrolysis, alcoholysis, ammonolysis,).

Reprocessed material

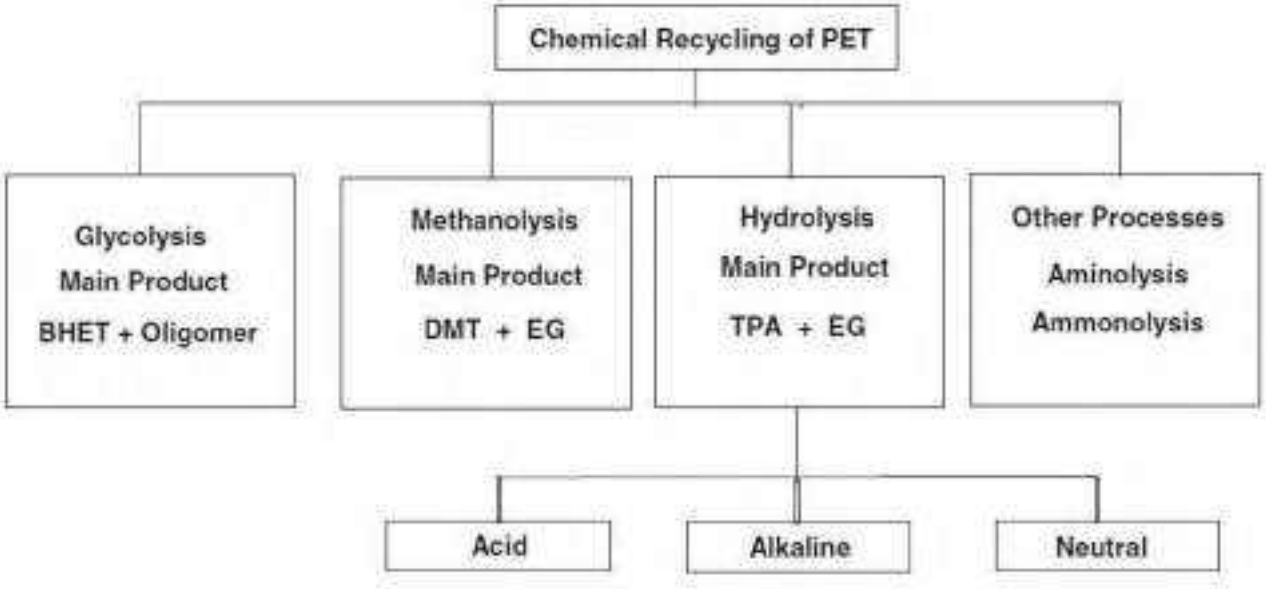
- Suitable for chemical recycling are polymers from cellulose, polyester, polyamide, polyurethane. Chemical recycling can be applied to recycle mixed or unmixed synthetic textile waste and gained products can be easily returned into the production cycle.

PROCESSING OF TEXTILE WASTE – CHEMICAL RECYCLING

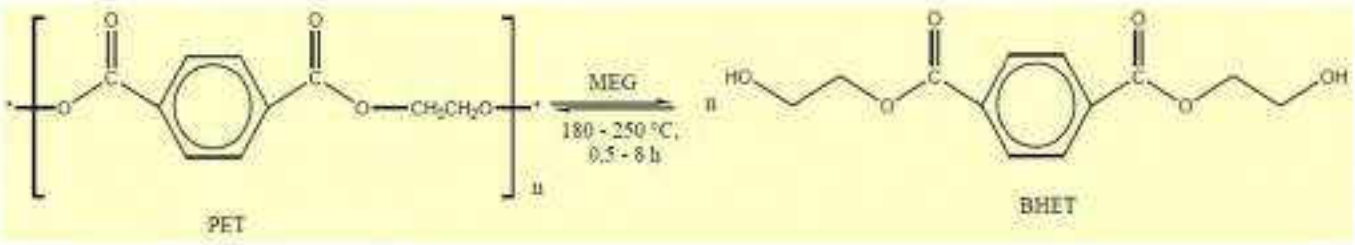


Source: Paper „Aktueller Stand der Technik zum Chemischen Recycling von Chemiefasern", Fachtagung des Innovationsforums „TexCycle" –Chemnitz (DE), 13 March 2019

PROCESSING OF TEXTILE WASTE – CHEMICAL RECYCLING



Example: Glycolysis of PET



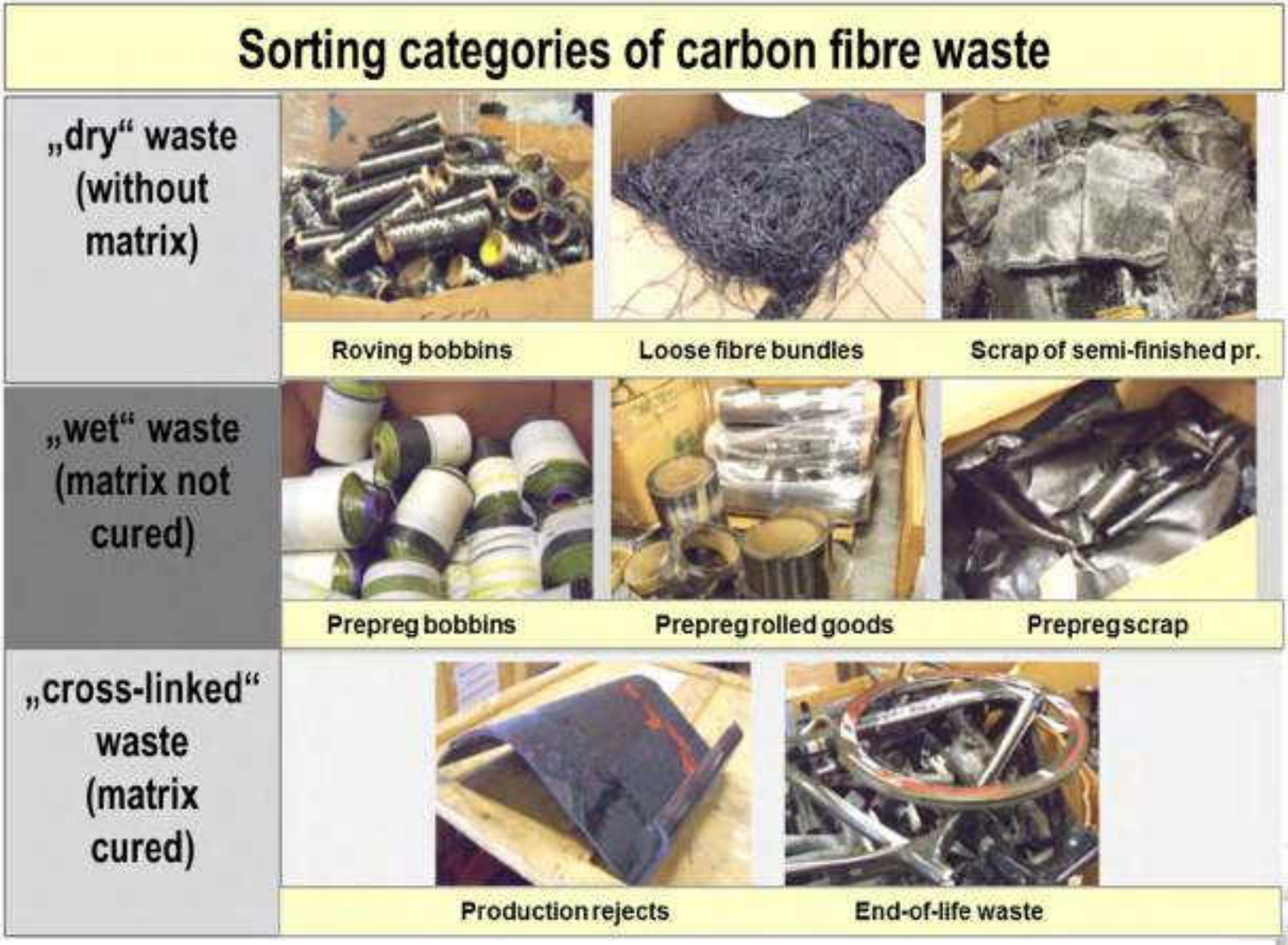
Source: Paper „Aktueller Stand der Technik zum Chemischen Recycling von Chemiefasern“, Fachtagung des Innovationsforums „TexCycle“ –Chemnitz (DE), 13 March 2019

RECYCLING OF SPECIAL WASTE – CARBON FIBRES

- 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 especially for lightweight applications.

Source: STFI

RECYCLING OF SPECIAL WASTE – CARBON FIBRES



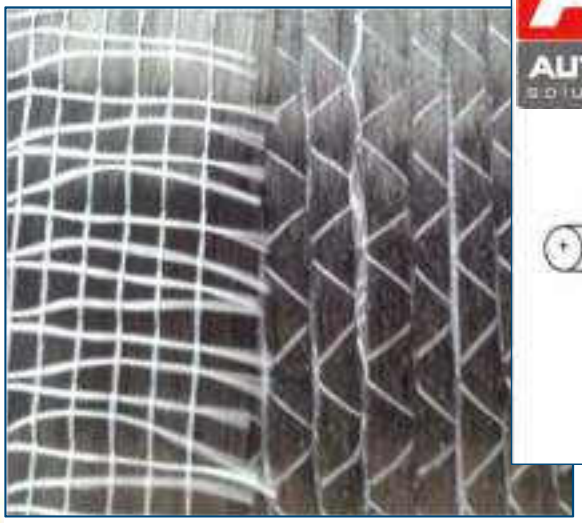
Source: Fraunhofer ICT

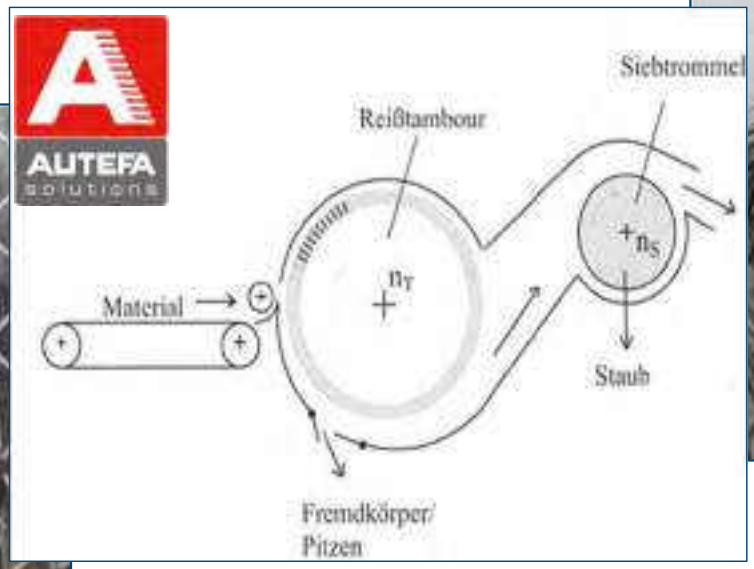
RECYCLING OF SPECIAL WASTE – CARBON FIBRES

Source: STFI

Pre-treatment step - tearing

- Receiving an average fibre length of about 85% of the precut, preferably 50 mm to 80 mm
- Technological developments for the transfer towards an industrial scale together with mechanical engineering companies
- Throughputs in the economically interesting range of 120 kg/h to 200 kg/h





Source: STFI

Stages of nonwoven production

Fibre opening

Web formation

Bonding

Source: STFI

RECYCLING OF SPECIAL WASTE – CARBON FIBRES

Source: STFI

TEXTILE WASTE FROM END-OF LIFE CLOTHING

There are three options regarding the waste management for used textiles and worn clothing.

1. They become **part of the residential waste** and are collected in bins for residual waste. They are not sorted and mixed together with other residential waste. This makes it completely unusable for any further use. Finally, it is incinerated (energetical exploitation) or disposed in landfills.

2. Larger quantities are **collected and handled centralized in recycling centres** operated by municipalities/city administrations or county governments. This is free of charge for registered citizens, companies have to pay a certain fee. A part of the used textiles is sold afterwards to sorting companies for further processing. The remaining part finally goes the same way as residential waste and ends-up in incineration plants or landfills.

TEXTILE WASTE FROM END-OF LIFE CLOTHING

3. Further collection of used textiles and worn clothing is organised by **private companies or charity organizations such as Red Cross or Worker's Samaritan Organization**. The collection of clothing is done via publicly accessible containers placed at spots easily accessible to many people, for instance near to shopping malls or streets which are highly frequented. The collected garments, textiles (home and household textiles, beddings) and shoes are sorted afterwards by quality criteria and distributed via clothing store (without money) or second-hand shops by selling to finance charitable and social projects. Furthermore, they are transported to third world countries and the part which is unusable is disposed.

Industrial sorting of used clothing at SOEX Recycling Germany GmbH, Bitterfeld-Wolfen (DE)
High standard sorting plant, sorting out by 400 criteria

- Sighting of material input
- Pre-sorting by type of clothing
- Sorting out by quality and material
- Capacity: 300 tons per day

Source: STFI at SOEX

Flow of material:

15 % tearing into reclaimed fibres
70 % secondary use (rags, clothes)
15 % refuse

www.soex.de

SOEX Recycling Germany GmbH, Bitterfeld-Wolfen (DE) High-scale production of reclaimed fibres from used clothing

Source: STFI at SOEX

- Tearing line with 1.90 m working width, seven cylinders
- Automatic separation of non-textile parts
- Machine manufacturer: Dell'Orco & Villani/Italy
- Throughput : 1500 to 2000 kg/hour, 24 hours per day, 46 tons per day

CONCLUSIONS – TRENDS IN TEXTILE RECYCLING

- **Structural changes** of the international, national and regional T&C sectors from the **classical production towards the production of technical textiles** are ongoing.
- Following this, the **textile waste is changing** concerning the kinds of **raw materials** (such as high performance fibres), the **composition** of textile fabrics, the **surface quality** (functional coatings), use of **electronic parts** in smart textiles, etc.
- **Technological solutions** to treat conventional textile waste are sufficiently available and **state-of-the art.**
- **New methods/approaches** to treat novel materials are required.
- New materials lead to a great variety of types of waste with small amounts of waste. Important is to **channel the waste streams** and **build up networks** for waste management at interregional level (for instance via a database).

CONTACT INFO

Saxon Textile Research Institute
Romy Naumann & Dr. Anna Große

http://www.stfi.de
https://www.interreg-central.eu/Content.Node/3.html

romy.naumann@stfi.de
anna.grosse@stfi.de