



## Research and identification of textile plants in the Nordic countries & Europe - focusing on fiber - to - fiber recycling for the fashion & textile industry

## Preface

One of the big questions for the textile industry now concerns how to close the textile loop? Different actors throughout the industry are seeking the answer to this question and working on business models, processes and techniques while establishing new collaborations that contribute to closing the textile loop. This publication will give you an insight into the growing industry and business opportunity of textile recycling. It will provide you with information on what materials textile plants are able to process and give you an overview of brands that are seeking the benefits of using recycled fibers, collaborating with take-back/sorting actors and/or sending leftovers from their production to plants that can process it. We hope that this publication will provide you with the knowledge needed in order to get inspired and become part of the circular textile industry of the future.

Please enjoy!

On behalf of Lifestyle & Design Cluster,  
*Gabriella Constantinou & Isabella Holmgaard*

## Introduction

This report gives an insight on important textile plants located in Europe working with fiber-to-fiber recycling. There are currently three categories/stages. Some are at a pilot stage meaning that they have found a solution of how to recycle in a lab and can test or produce on a very small scale. Others are at an operational stage making it possible to process bigger amounts of textile waste, however, not on a commercial scale yet, as they have encountered several challenges at this point. The last category are the commercial plants which are fully functionable processing high amounts of waste. This report will give information on which recycling process they are able to use, what type of materials, future plans, if relevant, and names on some of their collaborators. You can also find an overview of textile plants located in non- EU countries. Finally, seven field cases are developed on plants and fashion/interior brands to illustrate the value chain and innovative collaborations between different actors in the industry.

## Challenges to closing the textile loop

Redesign, remaking and recycling fiber-to-fiber have for centuries been a part of our life. E.g. in the eighteenth century the Napoleonic War caused virgin wool shortages which required that wool fibers be garneted into new yarns. However, recycling became less attractive and unnecessary in the late nineteenth century and beginning of 20th when man-made fibers were born. Suddenly the technical progress created no need for recycling anymore.

Nowadays non-organic raw materials are infused with a high variety of chemicals requiring different treatments under a recycling process. Today cotton-polyester blends, nylon PA6 and 100% polyester can be chemically recycled due to years of lab research and experimentation. On the other hand, fibers such as wool, cotton, camel, cashmere fibers can be mechanically recycled with the addition of a percentage of virgin fibers.

Using recycled materials is generally considered environmentally better but there are both advantages and disadvantages. In general, a recycling process is demanding and not many technological features are implemented yet as for instance material composition I.D. making it still a challenging field. During both the mechanical and chemical process many steps are needed e.g. characterization of materials/blends, separation of non-wanted components, materials, zippers, buttons, dyes and chemicals. Blends of e.g. cotton-pes or elastane can be highly time consuming to recycle due to the separation steps. While mechanically processed fibers are challenged in achieving an equal quality as a virgin material without adding any virgin fibers. 100% is typically not possible but the Italian textile plant Rifo adds 0% virgin fibers.

For these reasons recycled materials are today more expensive than virgin raw materials which continues to challenge the development of a circular textile industry.



Furthermore, energy consumption should be considered as it needs to be efficient and derive from renewable sources. A company like Re:newcell uses 100% renewable energy through its recycling process. It is likewise important to think about microfibers when recycling synthetic fibers such as polyester or nylon. These fibers will still carry microfibers when mechanically recycled and when washed they will be released into the ocean. This is one of the four most important challenges according to the Ellen MacArthur foundation in achieving a new textiles economy. Moreover, synthetic materials having non-biodegradable properties will need to be kept in a continuous recycled loop in order not to end in a landfill.

Recycling can be highly demanding when it comes to logistical support both in order to source, collect and sort the pre- or post-consumer waste overall.

An ecofriendly way of recycling is the ideal solution and would enable a more economic and ecological process of blended textiles. The answer might be found in a biochemical recycling process that uses lower temperatures and is highly material selective. "Green" recycling avoids additional waste streams and high energy consumption keeping the steps of the process in the context of sustainability.

IONCELL

UNITED FIBER

PURE WASTE

re:newcell

SÖDRA

convert

TEXTILECHANGE

I:CO

SAXCELL

Wolkat

worn again technologies

Refibra™

ReVerSo™

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O Operational

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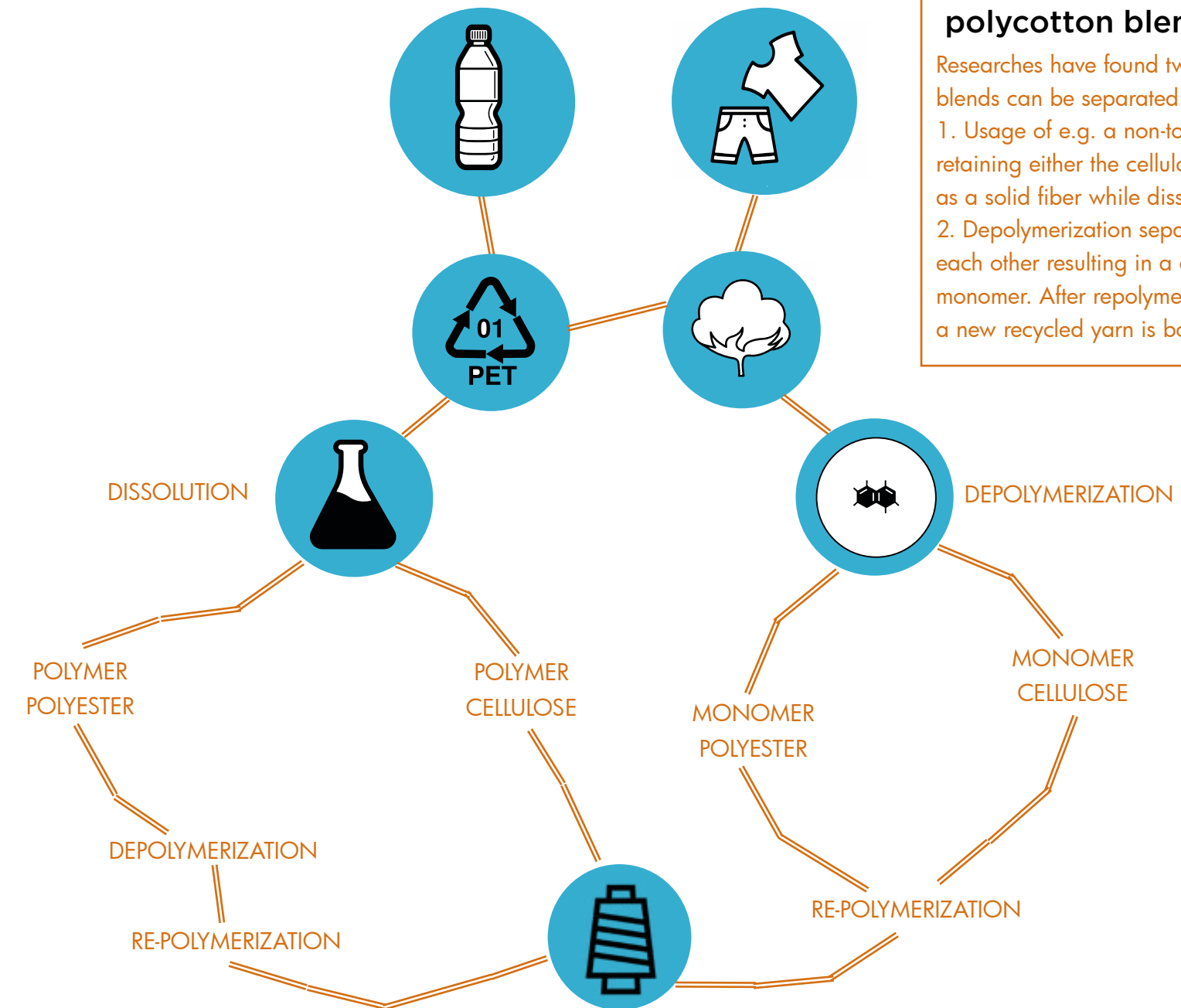
ReVerSo™

I:CO

PURE WASTE

100% RECYCLED TEXTILES

C Commercial



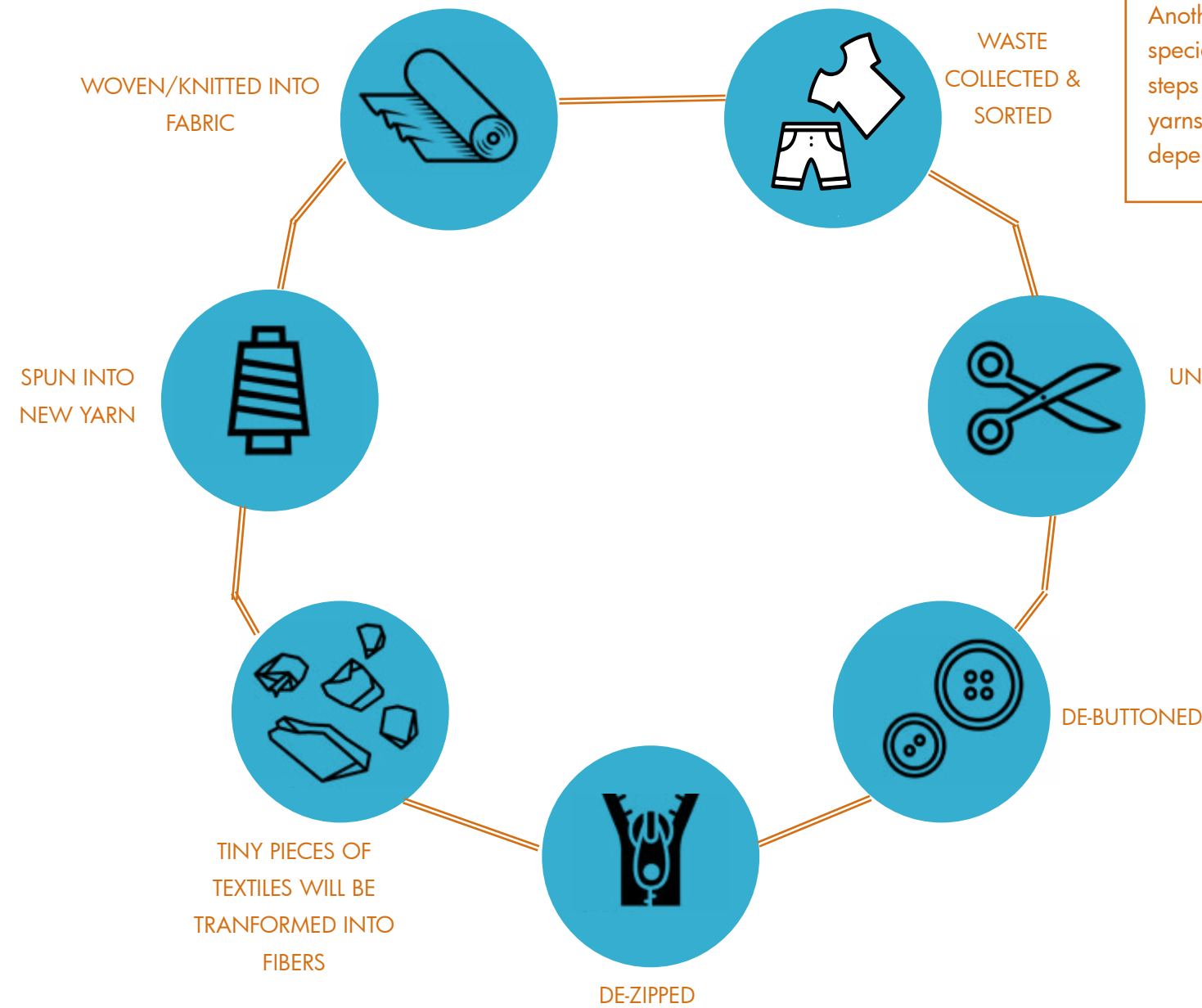
**polycotton blends**

Researches have found two ways polycotton blends can be separated:

1. Usage of e.g. a non-toxic dissolution liquid retaining either the cellulose or polyester polymer as a solid fiber while dissolving the other.
2. Depolymerization separates the two fibers from each other resulting in a cellulose or polyester monomer. After repolymerization of one the fibers, a new recycled yarn is born.

### from waste to fabric

Another way to recycle textile waste is by using specially engineered machinery. Through several steps it's possible to produce new yarns with or without the addition of virgin fibers depending on the fibers' length and strength.



### Symbol dictionary



Able to process cotton fibers as feedstock



Able to process wool fibers as feedstock



Able to process cashmere fibers as feedstock



Able to process camel fibers as feedstock



Able to process polyester materials as feedstock



Able to process nylon materials as feedstock



Production of recycled textiles suitable for apparel



Production of recycled textiles suitable for upholstery



Mechanical recycling process



Chemical recycling process

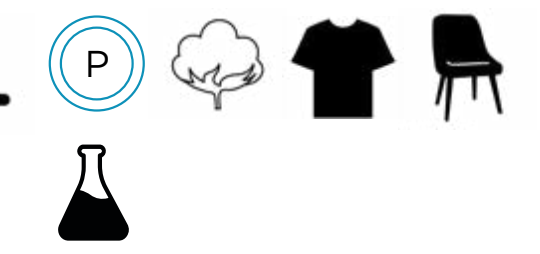


FINLAND

# IONCELL

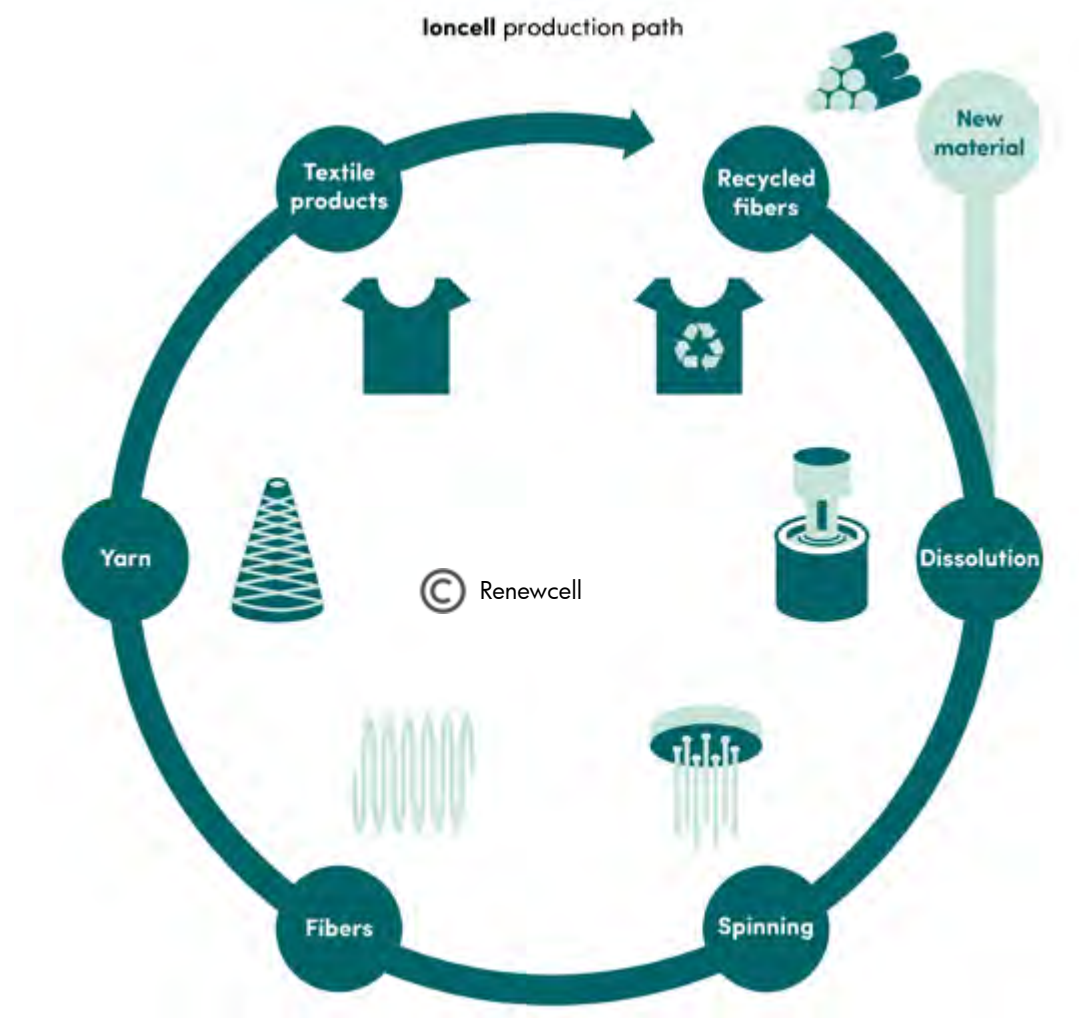
since 2011 |  
Aalto University & University of  
Helsinki

[www.ioncell.fi](http://www.ioncell.fi)

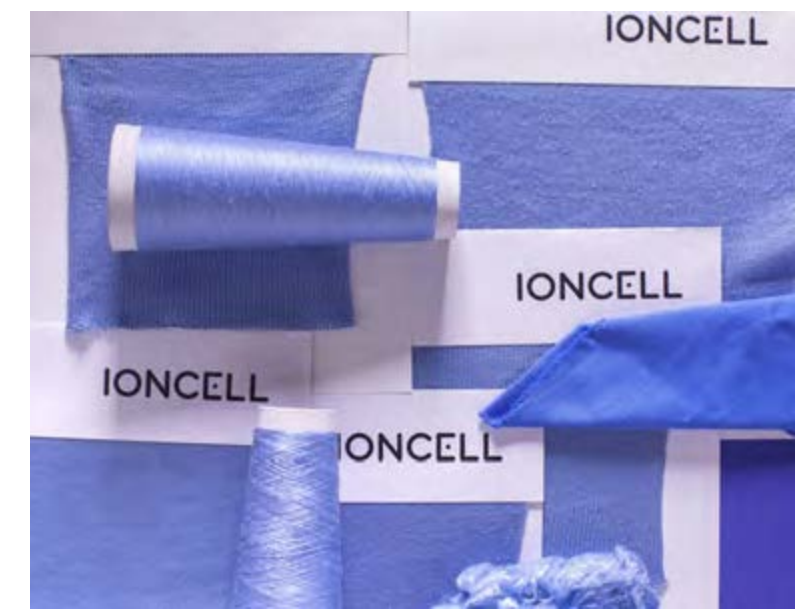


what

**Ioncell** technology develops new textiles derived from worn-out garments, pulp or even old newspapers. The technology can be applied to cellulosic waste; cotton, viscose, lyocell and both pre-industrial and post-consumer waste are used as raw material resource.

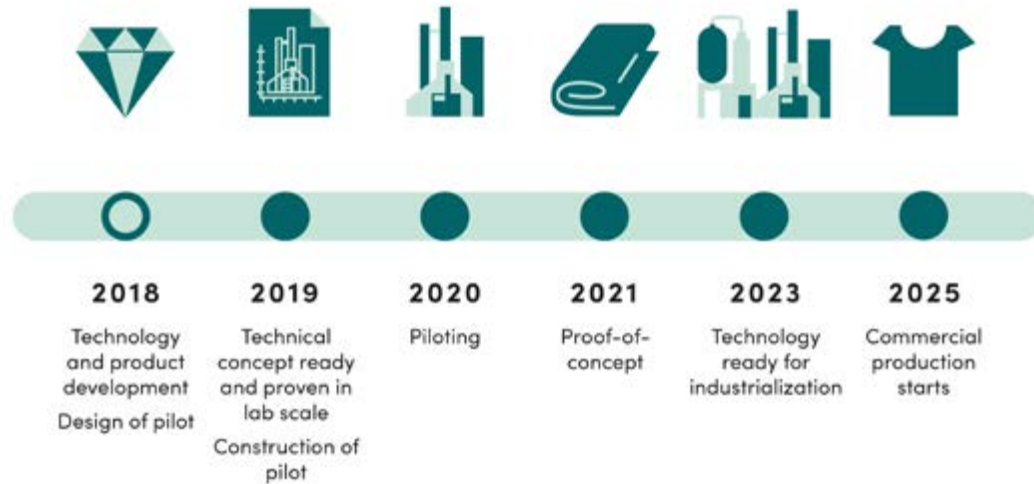


© Ioncell



© Ioncell





process & result

A solvent called ionic liquid dissolves the cellulosic textiles waste transforming it into a pulp. This pulp is then spun into fibers using a dry-jet wet spinning technology. Chemicals applied are the non-toxic ionic liquid and water both re-circulated in a closed loop process. Ioncell is moreover able to separate poly-cotton textile blends through the chemical process of dissolution. The dissolved cellulose derived from the cotton can be spun into new high-quality fibers similar to Lyocell. However, the separated polyester needs to be decomposed into polyester monomers and then re-polymerized for the production of recycled polyester yarn. Ioncell fibers are strong, soft, shiny and have equal or higher fiber properties to viscose and Tencel fabric. It's possible to dye Ioncell fabric just as any other natural fibers. Marimekko has prototyped a few designs made of Ioncell fabric using digital printing and knitting for home and fashion textiles.



© Marimekko



© Marimekko

collaborators:

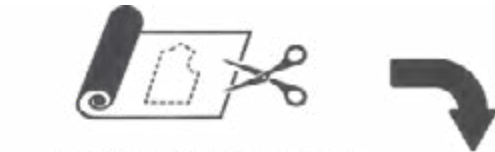
marimekko



PURE WASTE  
100% RECYCLED TEXTILES

since 2013 |  
Finland + India

[www.purewastetextiles.com](http://www.purewastetextiles.com)  
[www.purewaste.org](http://www.purewaste.org)



Our products are made of  
textile waste, leftover from the  
clothing manufacturing process.



We turn the fabrics  
o products that save  
huge amounts of  
fresh water.



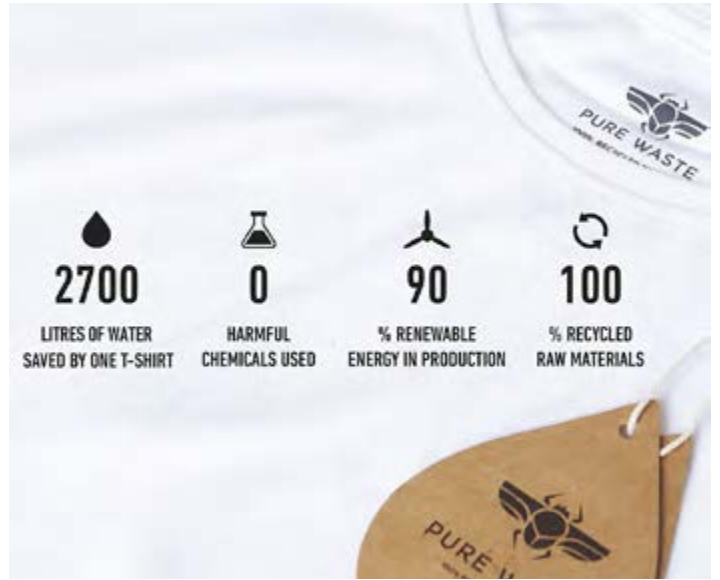
We first sort the  
waste by colour th  
we refiber and sp  
it into new yarn



This allows us to produce fabrics  
without dyeing and without  
use of fresh cotton.

what

**Pure Waste** uses cotton pre-consumer textile waste from the fashion industry in India. Raw material derives from two main sources; one is the yarn waste from the spinning and weaving process while the other is fabric offcuts when cutting out the patterns.



© Pure Waste

## process & result

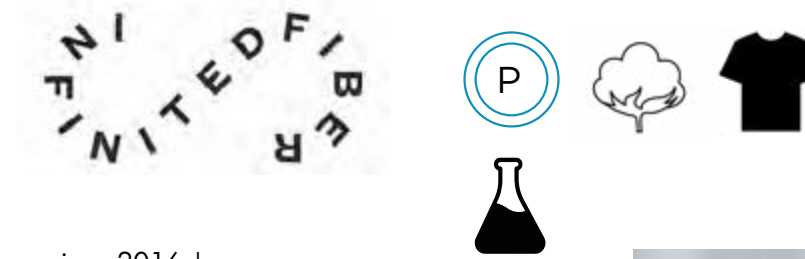
Pure Waste production takes place at a textile plant located in India. The recycling process is mechanical and occurs after collection and sorting has taken place. Sorting is done by colour meaning that a dyeing process is avoided. The process begins with shredding the pieces with a focus on keeping the length of the cotton fibers as long as possible. Blending the cotton fibers is followed and during this process it is possible to add chemically recycled polyester or viscose fibers to create a textile blend. In the end spinning the recycled yarns, knitting or weaving fabric for the usage of garments is executed.

### Pure Waste available

- Private label Pure Waste
- B2B
- Pure Waste products are distributed by selected partners
- Possible to purchase Pure Waste fabric



© Pure Waste



since 2016 |  
VTT Technical Research Center of  
Finland

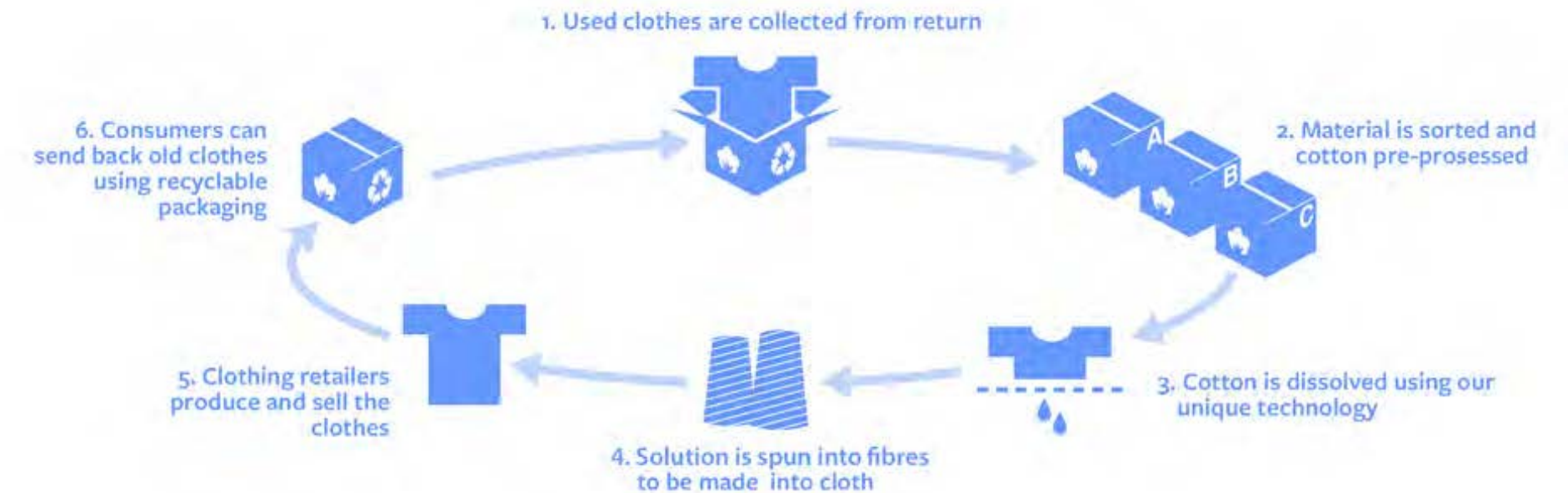
[www.infinitefiber.com](http://www.infinitefiber.com)



© Infinite Fiber Company

## what

**Infinite Fiber Company** technology has the ability to chemically process post-consumer cotton waste collected from their customer brands such as H&M and more. The textiles can be blends of cellulose and synthetic fibers but the feedstock must be of cotton content. Several brands have validated the Infinite fibers for example for denim use. IFC is also able to decompose cardboard and agricultural waste.



© Infinite Fiber Company



## process & result

The chemical process involves three necessary actions. Firstly shredding the waste is done, then a fiber separation is executed and here colours and finishing chemicals are being removed. Through IFC patented process synthetic fibers are removed e.g. polyester and elastane. A powder of cellulose carbamate is created and dissolved into a liquid followed by a transformation into a filament. Their technology uses less chemicals and 0% usage of virgin fibers, while the fabric absorbs up to 30-40% more colour in the dyeing process.

The yarns, textiles and non-woven fabrics are produced by IFC customer brands' facilities. One main characteristic of this textile plant is that the fibers can be recycled again and again without any loss of quality and material properties.

IFC textile has a similar feeling to cotton and highly suitable for clothing. If a brand is interested in a cellulose blend that is also possible depending on the properties of the end use of fabric. IFC produces the fibers and at the moment a new pilot plant is being build for sample and testing purposes for major customers.



© Infinited Fiber Company

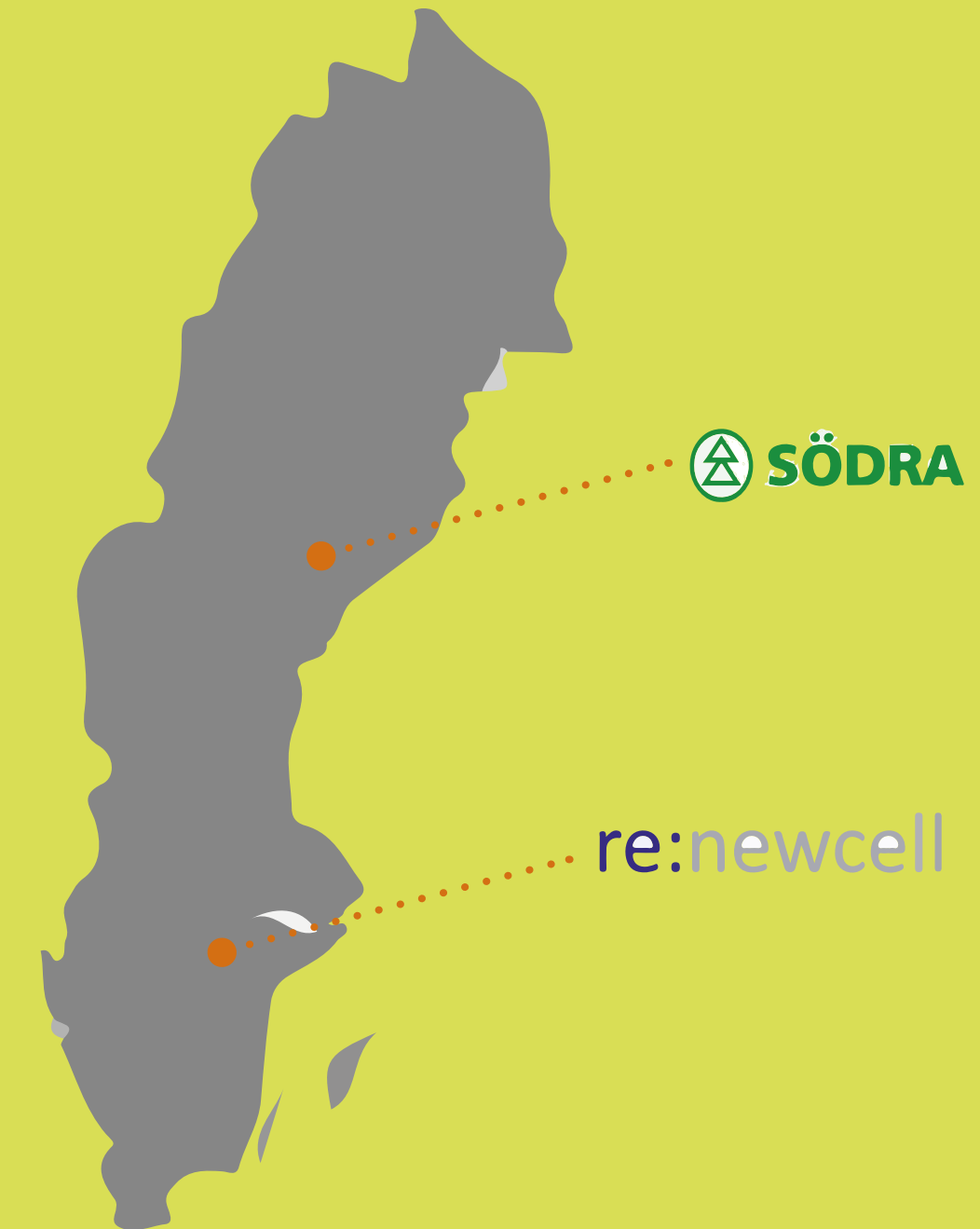
## future plans

- 2019 pilot plant is being build in Finland
- 2020-2021 first commercial scale production
- Responsible brands will be possible to purchase IFC fabric in the future
- Goal to licence technology on a global scale

collaborators:



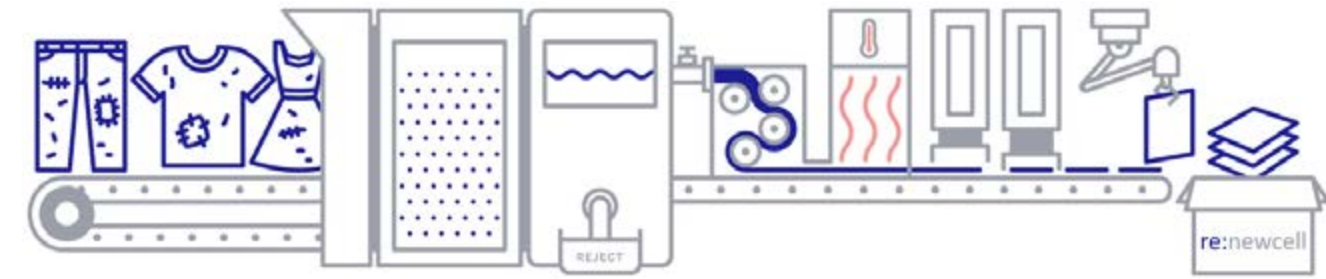
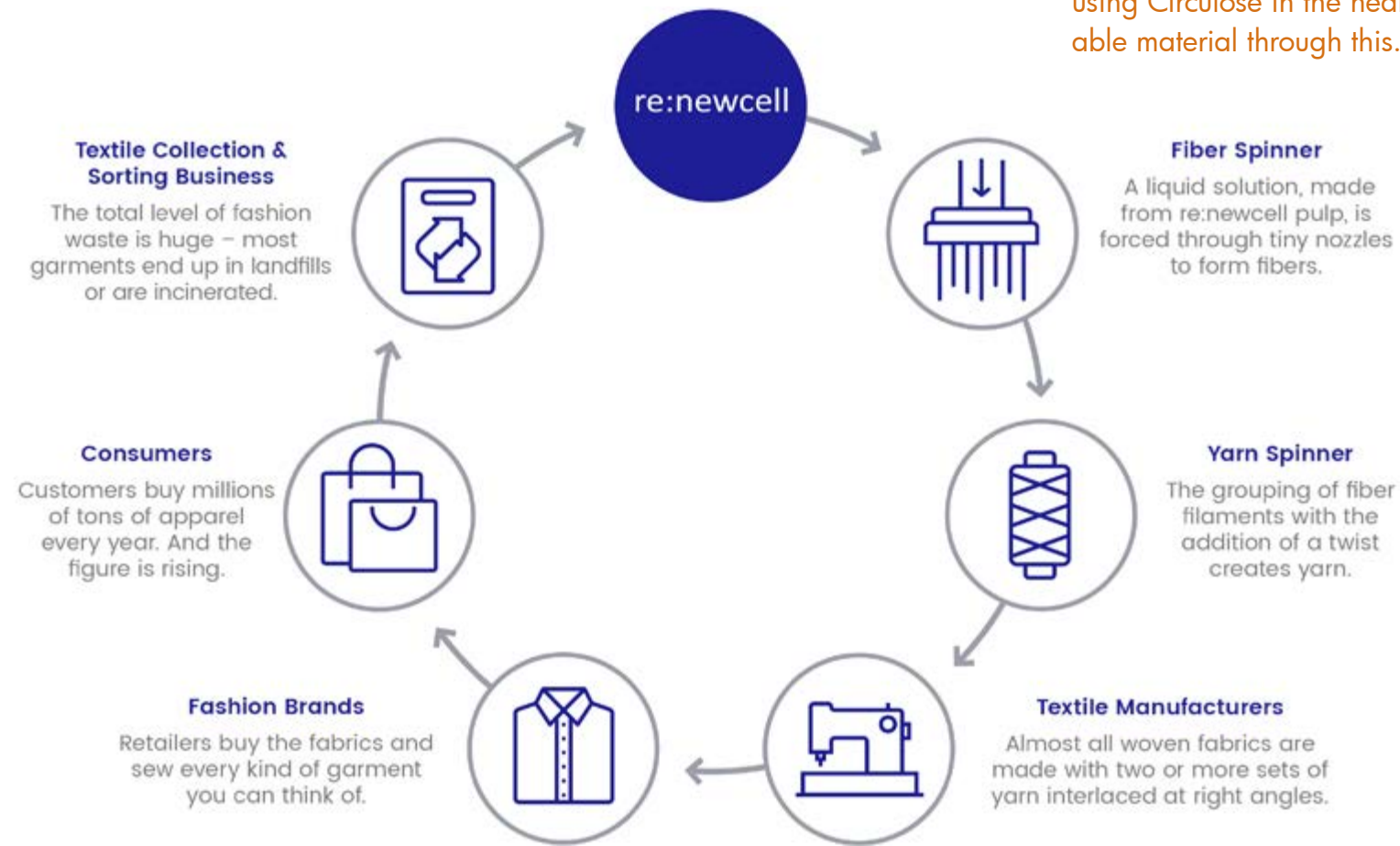
SWEDEN





what

**Re:newcell** technology is able to decompose cotton and viscose and other natural fibers containing very high levels of cellulose. Renewcell collaborates with several collectors and textile manufacturers and receives its pre-industrial waste from e.g. ISKO, Filippa K etc and post-consumer waste from I:CO, Texaid, EcoTlc and more. Textile waste is then processed in a closed-loop to create new garments. Re:newcell has now launched a new brand called Circulose which is similar to e.g. Gore Tex. Fashion Brands using Circulose in the near future can assure their use of a sustainable material through this.



process & result

Worn-out garments are shredded then de-buttoned, de-zipped mechanically, while dyes and non-cellulosic fibers e.g. elastane and polyester are chemically removed. A biodegradable dissolving pulp is created that is then dried into sheets of cellulosic content. These sheets are spun into yarn and woven into new textiles done by Re:newcells global textile manufacturers partners. At the moment 7.000 tons per year of pulp is produced in Kristinehamn, Sweden. The production process has the ability to reuse chemicals again and again using 100% renewable energy.



**Re:newcell will initially work with selected sustainability driven brands with more clout throughout the entire value chain. Some of these have their own outsourced supply chain and can design and create finished garments through their own selected partners starting with fiber. Other smaller brands and designers will be able to use our material through a pre-defined and traceable value chain with selected partners (pulp - fiber - yarn - fabric) We are currently testing these pre-defined value chains, but its not available for a wide range of brands yet.**

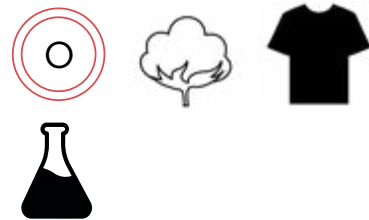
Richard Törnblom, CEO BluePearl AB

future plans

- Increase production
- To 30.000 tons per year
- Reach 1 billion tons per year
- Establish seven new textile plants globally
- 2020 Circulose garments will be available by 3 brands

collaborators:





## what

**Södra** is a Swedish textile plant that has so far been producing sustainable viscose and is now expanding to a fabric blend of wood pulp and post-consumer waste. Södra focuses on white textiles for now, therefore the kind of textiles used are e.g. towels, bathrobes, bed sheets, napkins mainly from the Danish company Berendsen that leases white textiles to hotels, hospitals, spas etc. Södra is currently limited to white textiles until a decoloring method is found.



© Södra

## future plans

- Higher amount of used textiles in the final product such as 50%
- 2020 increase to 10-20%
- 2020 the goal is to produce 300 tonnes up until now it has been 20 tonnes
- Large-scale production
- If interested it's possible to fill out a form on [www.oncemore.sodra.com](http://www.oncemore.sodra.com)

## collaborators:



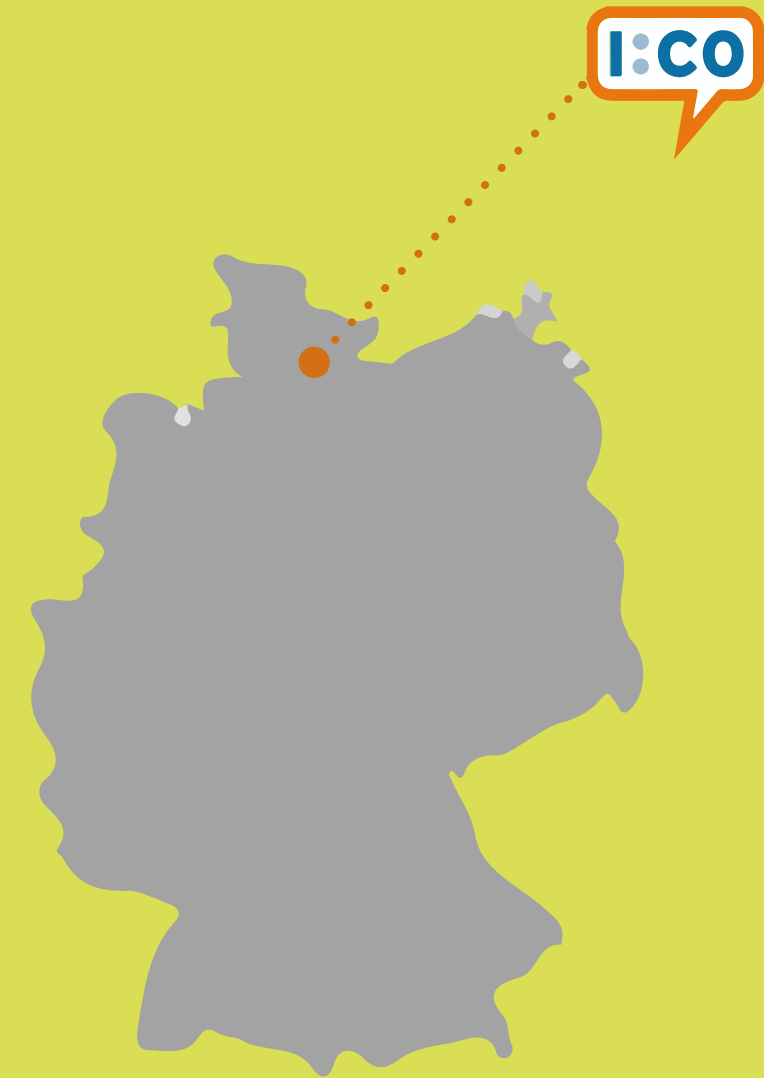


process & result

The several steps in the mechanical process include shredding textile waste and through cafting the fibers transform into a nonwoven mat. Caft-former is a machine patented method the Danish company Advanced Nonwoven has obtained, where mats from 1 to 100mm roll through. By use of an oven the right temperature for each material is obtained. Then a cooling phase takes place followed by a cutting process. Automated stacking is one of the last steps and as the final step DALT spary is applied; an advanced system for coating and treatment of fibers. The very last step is pressing these into the wanted shape depending on the end product. Products can vary from company to company.

what

**Convert** transforms textile waste, PET, used carpets or even wood and glass fibers into non-woven mats of various heights depending on the end usage.





since 2008 |  
SOEX, Germany

www.ico-spirit.com

## what

**I:CO** is a company with an expertise in global solutions within three main areas; collection, reuse and recycling. Through the 51 global partners of I:CO a brand can either set up a collection point of post-consumer waste in store or online. When consumers are ready to give their clothing and shoes a 2nd life a reward is given to the customer for bringing their used items back. At the moment I:CO has established sorting & recycling facilities in 60 countries.



© I:CO

## process & result

Sorting is done manually by evaluating 350 factors of the worn-out garments' and shoes' condition. Material identification and separation happens using automated methods. Approximately 50% of the sorted items is given a 2nd life at shops I:CO collaborates with. Then 60% is recycled in an open-loop involving various industries such as automotive and construction serving as insulation materials. 40% is then integrated in a closed-loop recycling. The recovered fibers are spun into new yarns reentering the various partners own supply chain.

## key activities towards circularity

- Circularity projects with global partners and network
- Encouraging innovation projects focused textile-to-textile closed-loop
- Advanced new recycling methods
- Innovative denim projects with recycled yarns
- 1st shoe recycling plant by SOEX through mechanical process
- Disassembling all types of shoes
- New shoe soles made of granulated rubber



© I:CO

collaborators:





SAXCELL

since 2011 |  
Saxion University of  
Applied Sciences  
Holland

[www.saxcell.nl](http://www.saxcell.nl)



## what

**SaXcell** technology uses a chemical process to recycle post-consumer cotton waste with the highest possible cellulosic content for the end usage of textiles within fashion and interior design.

1	•Textile waste collection and sorting
2	•Unravelling and/or milling
3	•Removal of polyester and other impurities
4	•Discolouration of remaining textile waste
5	•Adjustment of the degree of polymerization (DP)
6	•Spinning of SaXcell™ fibers
7	•Yarn production
8	•Fabric production
9	•Fabric finishing
10	•Tailoring





## process & result

The process begins with manually sorting, the worn-out garments are grinded and chemically decoloured. Spinning of yarn takes place using a similar technique to Lyocell and Viscose production; through wet-spinning. The advantage is that the production of Saxcell fibers can easily be implemented in already existing installations globally only with a few adjustments. Resulting in a regenerated cellulose fiber ideal for garment designs; Saxcell fibers can either be weaved or knitted into fabrics. It is possible to dye at the fiber, yarn or fabric stage.



## future plans

- Now 5.000 kg
- Future 10.000 tons per year
- 2020 textile plant planned to be build



© SaXcell

## collaborators:



since 2014 |  
Tilburg, Holland + Morocco

[www.wolkat.com](http://www.wolkat.com)

## what

**Wolkat** consists of seven international innovative recycling companies, therefore Wolkat has the ability to control the various steps towards the re-developing of new materials. Wolkat collaborates with municipalities, government agencies and private companies in collecting textile waste.

## process & result

From collecting, sorting, recycling into new recycled textiles and further on creating new products for fashion, furniture and automotive purposes is what Wolkat facilitates in-house. In 2014 the company was able to spin own yarns in-house and in 2016 it established its own weaving mill. An amount of 25 million kilos are processed each year by Wolkat.

Wolkat has collaborated with brands such as Nike on a development project of a recycled gift bag made out of PET bottle waste. Moreover the brand Filippa K has worked with Wolkat on a recycled polyester material made of PET bottles for a coat design. Wolkat weaves, knits and moreover creates non-woven textiles.



© Wolkat

## collaborators:

Filippa K





UNITED KINGDOM

**worn again**  
technologies

since 2012 |  
United Kingdom

[www.wornagain.co.uk](http://www.wornagain.co.uk)



what

**Worn Again technologies** has two main sources of waste. The one consists of post-consumer waste of textile blend of cotton and polyester of various percentages, while the other one are PET bottles and packaging. These are transformed into new raw textiles.





process & result

The technology applied is able to separate polycotton blends by firstly a decontamination process followed by an extraction process of polyester and cellulose polymers. These are then used to spin new yarn and then fabric for garments. 80% of post-consumer waste is suitable for Worn Again's technology and can therefore be re-incorporated in the closed loop system. Worn Again holds a 'Cradle to cradle' certificate since 2018 and is moreover part of the Ellen MacArthur Foundation and Fashion for good. H&M is one of their investors and so are the brands Kering and Himes sustainable wear.



© Worn Again Technologies

- future plans
- 2020 textile pilot plant build
  - Now 5.000 kg
  - Future 10.000 tons per year

collaborators:



AUSTRIA





since 1938 |  
Lenzing Group  
Austria



www.tencel.com

### what

**TENCEL™ Lyocell fibers with REFIBRA™ technology** is a cellulose material created of 100% cotton pre-consumer waste combined with wood pulp tencel.



© Tencel



© Tencel

### process & result

Through a chemical process consisting of six different steps cotton offcuts are combined with wood pulp. A solvent is added to the mixture being reused 99.7% in a closed loop. Moreover a fiber ID is entered for transparency at any stage of the process. The final product is a biodegradable fabric suitable for the fashion industry. A future goal is to also incorporate post-consumer waste. TENCEL™ Lyocell fibers with REFIBRA™ technology is available in commercial volumes for design brands globally.

collaborators:

Candiani  
DENIM

Kings Of Indigo

ADVANCE  
DENIM

patagonia

BO  
TEJIDOS ROYO



© Carved in blue



© Tejidos Royo

**ECONYL®**

ReVerSo™

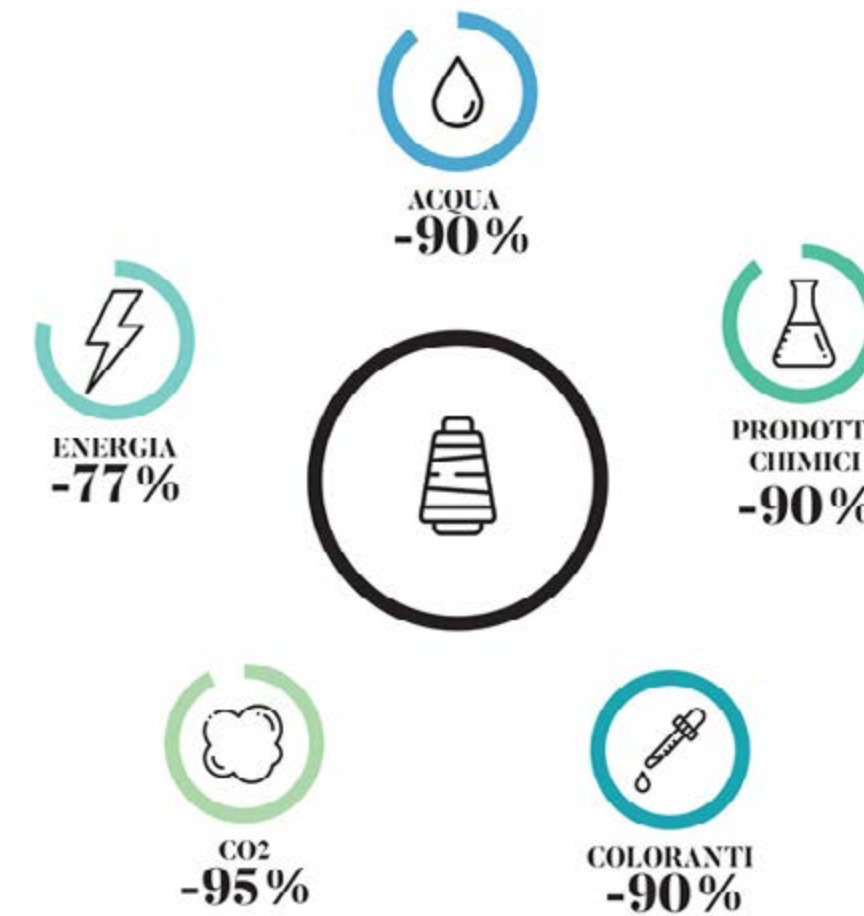
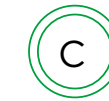


ITALY



since 2017 |  
Prato, Italy

[www.rifo-lab.com](http://www.rifo-lab.com)



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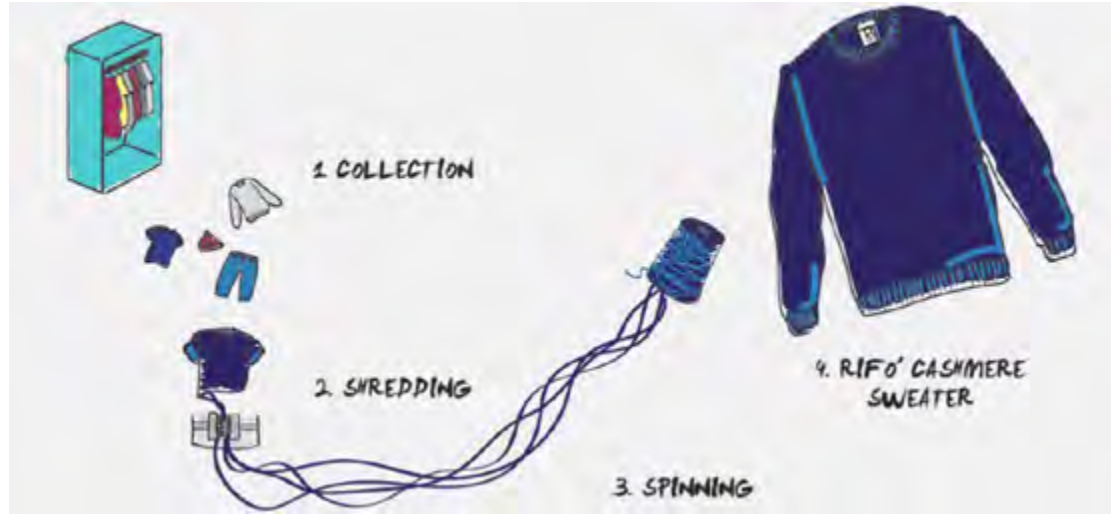
## what

**Rifó** has several local and global collaborators for collecting post-consumer waste. Worn-out jeans derive mainly from Southern Europe while cashmere garments are collected in the US. Rifó has started a collecting service of post-consumer cashmere waste in Italy for its customers. Brands can purchase apparel products designed and made by Rifó.



© Rifó





© Rifo

### process & result

Worn-out jeans and old cashmere garments are through a mechanical process shredded and re-spun into yarns. The process needs no re-dyeing since it's possible to keep the original colour of the worn-out apparel. The yarns vary between three shades of blue made of jeans waste, while cashmere yarns vary in different colours. The recycled yarns are perfect for knitting new apparel and accessories. Moreover no need of adding virgin fibers is needed since the fibers are already long enough. Private customers and brands buy directly from Rifo ecommerce platform.



© Rifo

### future plans

- Establishing collecting services in other countries too
- Soon launching new products made of woven fabrics

# Re.Verso™

since 2014 |  
Prato, Italy

www.re-verso.com

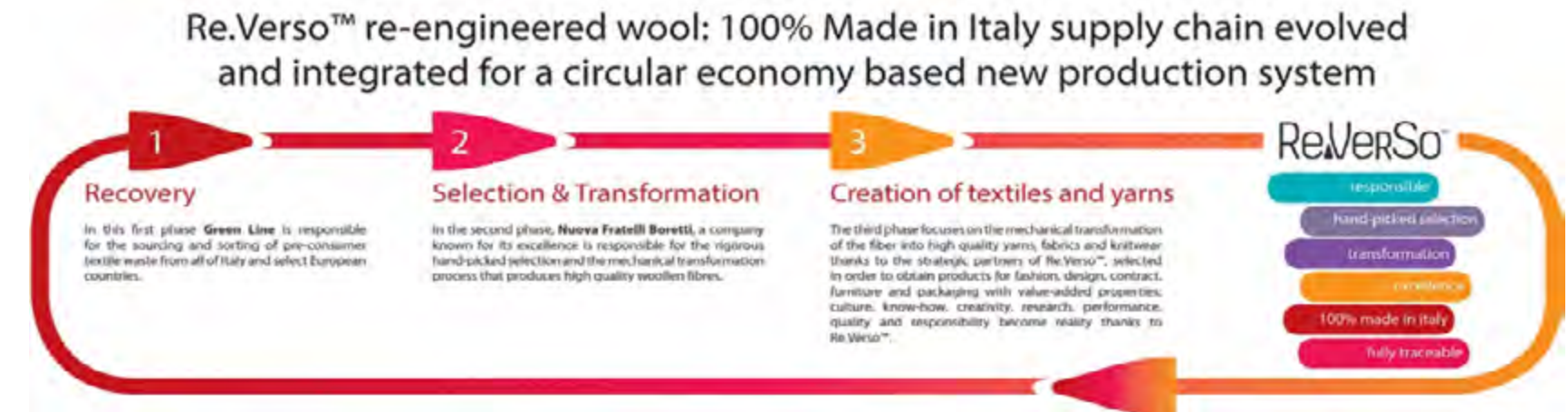


what



© Re.Verso

**Re.Verso** is an identifying trademark standing for high-quality recycled wool materials 'Made in Italy' with a well established textile system based in Italy. The trademark consists of several partners such as Green Line, Nuova Fratelli Boretti and several Italian manufacturers for yarn, fabric and knitwear supply. Green Line responsibly sources pre-consumer cut offs from Italy and selected European countries. While Nuova Fratelli Boretti takes care of the mechanical process of transforming waste into fibers of various wool qualities such as cashmere and camel fibers. Re.Verso holds certificates such as Global Recycling Standard, ISO 9001 and SA8000.



© Re.Verso



## process & result

The process applied is mechanical and results in re-engineered wool, cashmere and camel fibers. These are then knitted or woven by Re.Versos Italian collaborators into fabrics for fashion and home textiles. Re.Verso sorts the textile waste by colour. Filippa K collaborates with Re.Verso by sending wool fabric cutting waste to one of their Italian fabric manufacturers in order for this to be reused and recycled.



© Stelloni Mapel



© Nuova Fratelli Boretti

## collaborators:

Filippa K FARRAH FLOYD



filpucci

**ECONYL®**



## what

**Aquafil** created the Econyl brand five years ago and produces today recycled nylon yarns using two primary material sources. One being pre-consumer and post-consumer waste and the other one being used fishing nets and carpets.



© Econyl

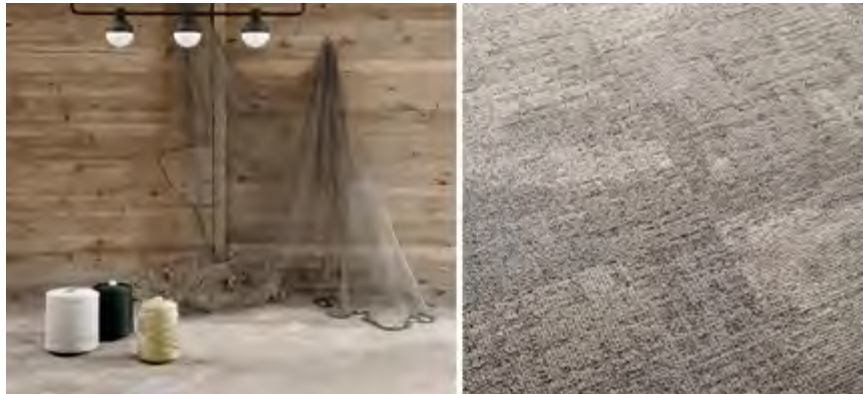


process & result

Both waste streams are shredded to begin with followed by a removal of contaminants. A depolymerization phase takes place at a plant in Slovenia breaking down the nylon PA6 to a monomer stage followed then by a polymerizing process. It's possible to regenerate the Econyl yarns over and over. Econyls process results in a variety of yarns for the fashion and textile sector; swimsuits, sportswear and carpets. Econyl yarns are used by many apparel and interior design brands, such as Adidas, Swedish Stockings, Ege carpets and many more.



© Aquafil



© Ege carpets

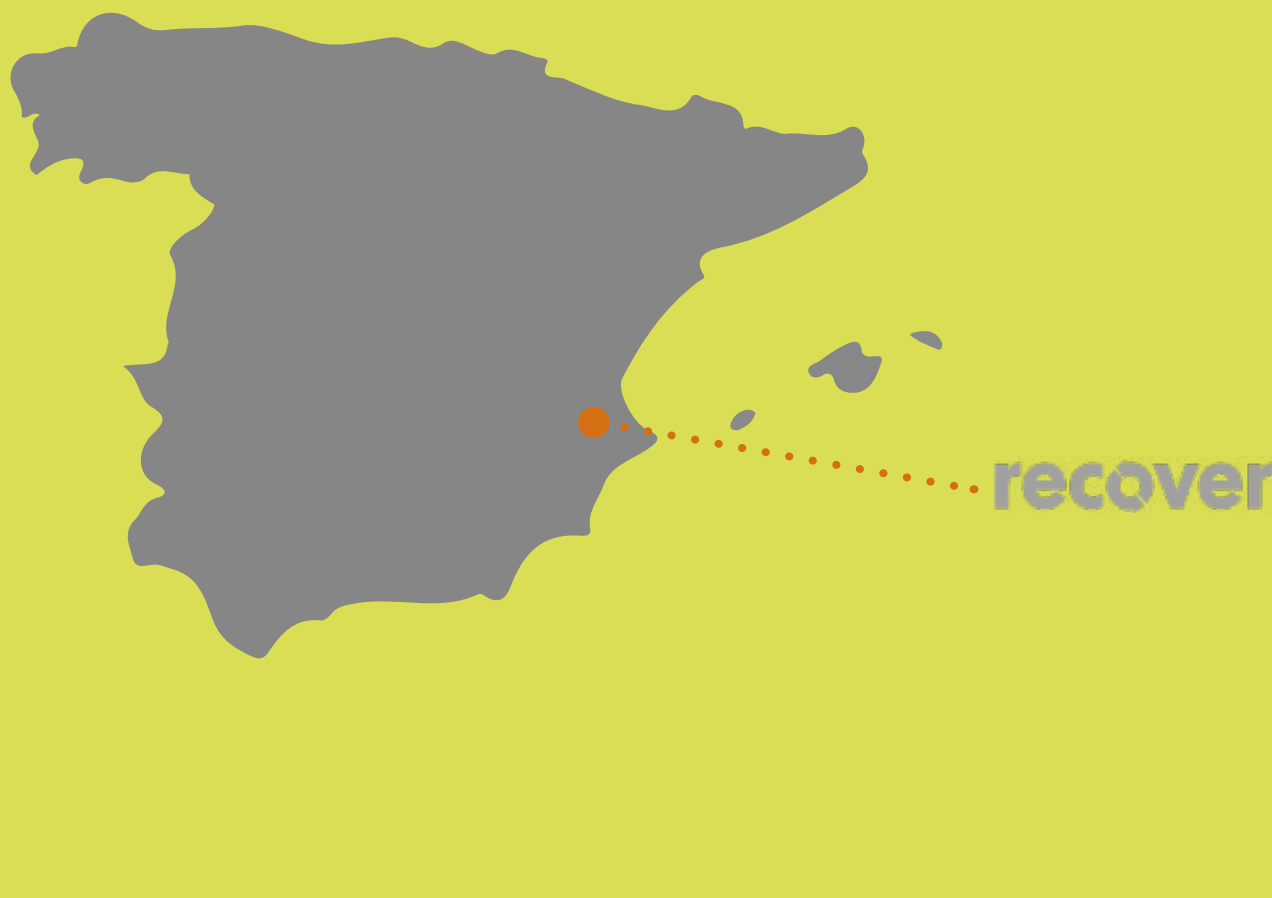


© Econyl

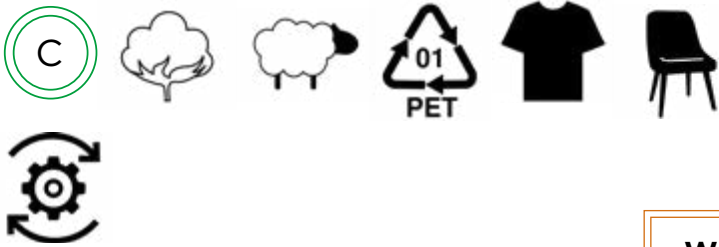
collaborators:



SPAIN



recover®



since 2015 |  
Hilaturas Ferre  
Valencia, Spain

www.recovertext.com

what

**Recover** produces nowadays seven different textiles. These consist of various blends of upcycled cotton, pre- and post-consumer denim waste, PET bottles, post-industrial wool, virgin organic cotton and tencel.



© Recover

process & result

The process of Recover is mechanical where the first step is cutting, then shredding and through machinery processed in order for the waste to be spun into new yarns. The yarns become fabrics for both the fashion and interior design industry.



© Recover



© Recover

collaborators:





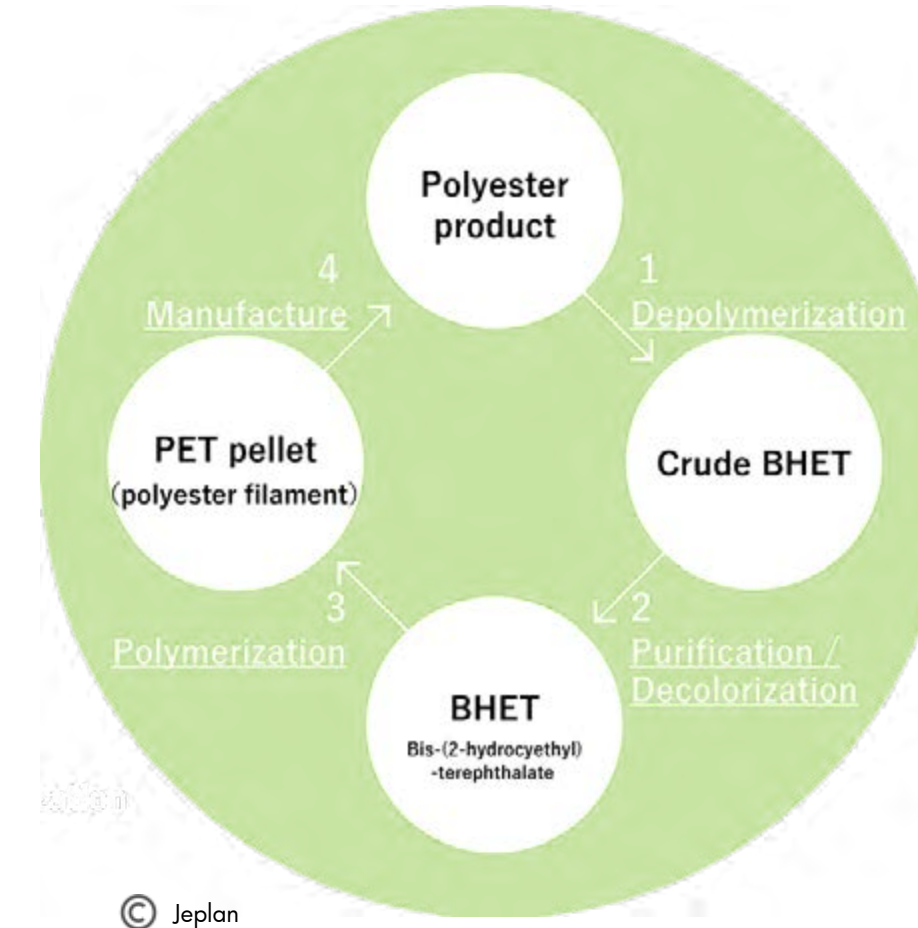
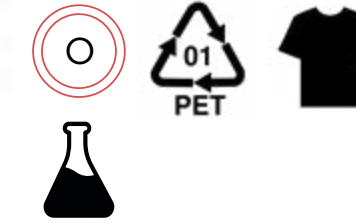


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[www.jeplan.co.jp](http://www.jeplan.co.jp)



## what

**Jeplan** has the ability to produce recycled polyester yarn from post-consumer textile waste. This is a method that hasn't been possible in Europe, since most textile plants are able to create polyester yarn from PET bottles and not clothing. Since 2010 a collecting system with the name 'Bring' has been established by Jeplan in Japan. It started with 50 spots in physical stores of various Japanese and non-Japanese brands. This number has now exceeded to approximately 2.800 spots in Japan and the future goal is to increase this to 10.000 spots. More than 100 million tons of clothing are discarded each year in Japan and 90% of these have been incinerated until now.



process & result

Through Jeplan’s patented chemical process a manual sorting has to happen to begin with in one of their plants in Japan. The post-consumer waste is mechanically shredded where afterwards a depolymerization method follows and this is how a polyester monomer is born BHET. A purification phase is needed to remove any irrelevant materials such as cotton etc and other components. Futhermore buttons and zippers are also being recycled after their removal. The end product of this chemical process is PET pellets which are then spun into yarn through Jeplan’s Japanese textile partners.



- future plans**
- Increasing collecting spots to 10,000
  - 2021 1st pilot plant in Europe
  - In collaboration with the French Cluster Techtera in Lyon

collaborators:



Cases

Cases have been developed with three textile plants of each category: pilot, operational and commercial comprising four Danish brands and a Dutch fashion & interior brand. These focus on four points of the recycling value chain collecting & sorting, recycling process, production steps such as spinning fibers, dyeing, knitting or weaving and end of life. The way these cases are structured gives an insight in the four steps and which partners/collaborators are active under which step of the process.

re:newcell

ReVerSo™



WALK ON MOONS



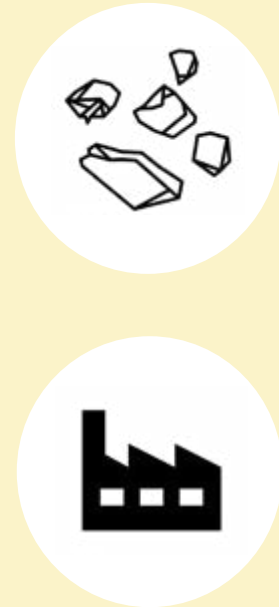
ege®

## Recycling value chain

### Collecting & Sorting



### Recycling process



### Production



### Life Cycle



### Collecting & Sorting



Who does the collection and sorting of post-consumer waste?

### Recycling process



Who does the recycling?  
What does the process look like?

### Production



Who is behind the spinning of fibers, dyeing, finishing, knitting or weaving?

### Life cycle



Who is part of the life cycle?  
How does pre-industrial textiles re-enter the textile loop?





## Collecting & Sorting



## Recycling process



## Production



## Life cycle



re:newcell

H&M

ISKO™

SHASHA  
DENIMS



CIRCULOSE



Re:newcell relies on the collection & sorting from third parties. These stakeholders are sorters, traders, pre-consumer waste suppliers. This eco-system of waste suppliers was built by initially having tried and tested various batches from different sources.



The recycling process from mechanically shredding to the chemical removal of dyes and other components until the production of the cellulosic sheets happens at the Re:newcell plant in Kristinehamn, Sweden. At the moment 7.000 tons per year of pulp is produced in Kristinehamn, Sweden. The production process has the ability to reuse chemicals again and again using 100% renewable energy. Their future plans include establishing 7 new textile plants. Two in China, one in India, one in Germany and finally one in the US.

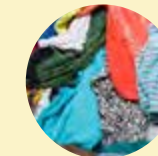


After the production of cellulosic sheets these are finally spun into yarn and woven into new textiles done by Re:newcells global textile manufacturers partners. There are various stakeholders involved in this step e.g. fiber spinners, yarn spinners, weavers, sewers, designers, purchasers from brands or retailers. The most concentrated part of the value chain is the fiber spinners large international companies, where of the ten largest have more than the majority of the global production. Re:newcell has five fiber spinners as validation partners in Asia, Europe, US.

**- The larger global fashion brands have pre-defined value chains with trusted parties throughout the chain whom they use for different collections and pieces. Moreover the company is in close discussion with 50+ fashion houses who demand a specific kind of dissolving pulp e.g Circulose.**

**- Re:newcell also works on establishing pre-defined value chains in-between fiber spinner and brands to facilitate purchase of fabric made from Circulose. This is especially important for smaller brands, who are used to only buying fabric and do not have relationships throughout the entire value chain.**

Richard Törnblom, CEO BluePearl AB



In the future Re:newcell will most likely create a take-back system although this is largely dependent on a more mature collection and sorting business. Circulose can be recycled again and again.



## Collecting & Sorting



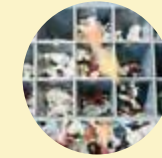
## Recycling process



## Production



## Life cycle



**Re.Verso** has established a partnership between several textile manufactures in Italy that each have their role in textile recycling value chain.

The company Green Line responsibly sources pre-consumer cut-offs from Italy and selected European countries.



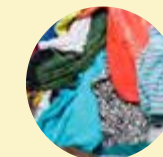
Nuova Fratelli Boretti takes care of the mechanical recycling process and transforming post-consumer waste collected and sorted by Green Line into fibers of various wool qualities such as cashmere and camel fibers.



In the production phase one of the fiber spinners is the Italian company Filpucci based in Tuscany. It is known for its superior knitwear yarns and has several plants in the area for twisting, dyeing and spinning yarns.

The other spinner company is Filatura C4 specializing in high-quality and performance yarns using recycled and eco-raw materials among others.

Stelloni Mapel is also an Italian fabric manufacturer producing knitted wool and mohair fabrics and fake furs for fashion clothing but also shoe lining and upholstery. Moreover they can produce more technical fabrics for e.g. paintrollers and cleaning usage.



In the end of a life cycle fashion brands have the possibility of sending their wool pre-industrial waste as f.x. Filippa K has tried out, in order for it to be used in the production of recycled yarns.







# WALK ON MOONS

Walk on Moons doesn't follow the traditional design thinking which is the reason that Walk on Moons collections are not built around current trends. Materials can derive from e.g. deadstock affecting the final collection in a positive outcome since designs may vary giving a more unique character to the clothing.

According to Henrik Spandet-Møller, the CEO of the brand, in the future digitization might be a way Walk on Moons will evolve in e.g. by being able to track & trace the journey of a product enabling the end user to get all the needed information about his product.

Walk on Moons is to a great extent open to the evolution of sustainability, the future looks exciting and also unknown. Henrik Spandet-Møller believes that customers nowadays are very challenged on what is actually sustainable clothing and one of the reasons is that there are far too many certifications.



© Walk on moons



since 2013 |  
The Netherlands  
[www.mudjeans.eu](http://www.mudjeans.eu)







**MUD Jeans** works through 2 channels for collecting their own post-consumer waste. Their customers receive a 10 euro discount voucher for returning a used pair of MUD Jeans, but they do also accept other brands if the material consists of minimum 96% cotton. The other channel is through a leasing system for a monthly fee, where customers can lease a pair of jeans up to 1 year and then switch or return for recycling as wanted.



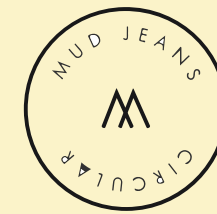
Post-consumer waste can be challenging to recycle as fiber-to-fiber according the CEO of the company, Bert van Son, if the end result should perform as a virgin material. Therefore MUD Jeans has partnered up with the textile plant Recover in Valencia, Spain since 2015. Actually in the beginning of their collaboration MUD Jeans was faced with the challenge of too low volume of recycling material making the recycling journey difficult, although this isn't an issue nowadays. Recover works with a mechanical process, the one recycled material is a blend of 23% recycled cotton, 2% elastane & 75% organic cotton. The other one consists of 40% recycled & 60% organic cotton. MUD Jeans is working on a research project that covers chemical recycling in collaboration with textile plants Saxcell and Recover in order to recycle the viscose part which currently isn't suitable for jeans material.



After receiving post-consumer jeans these are sent to Recover for the recycling process to begin. Hilaturas Ferre a neighbor factory is also involved in the recycling process. First the metal parts from the jeans are removed and then cutting and shredding can begin. The small pieces of cotton are then blended with new organic cotton fibers. Tejidos Royo also located in Valencia Spain is a sustainable textile manufacturer and is responsible for spinning the fibers, indigo dyeing of the yarns and finally weaving the material.



In the end of a life cycle MUD Jeans are active by offering a repairing service which is a big part of their business model and also mission, as a sustainable circular company. For example MUD Jeans encourages their customers to repair locally and not to send their jeans to the Netherlands to be repaired. The way it works: the receipt will be sent to MUD Jeans when using a local seamstress – this is also a way of supporting jobs locally, as they perceive themselves as a social enterprise company covering both the financial, social and environmental elements.



Bert van Son says that in the future MUD Jeans might start using a cotton and hemp blend to prolong the lifetime of the products. Hemp is a sustainably produced alternative with several similar properties to cotton. They do not wish to use polyester because of its non-sustainable qualities and also being a synthetic material the mono-material effect will disappear.

For MUD Jeans being transparent is part of their mission and a conscious marketing choice. They wish to see the change in the fashion & textile industry accelerate as fast as possible. Another highly positive outcome of being transparent is that customers become more educated asking questions about the production process, materials etc. Transparency attracts end users interested in a sustainable lifestyle.







## Collecting &amp; Sorting



**Gai-lisva** has a close relationship with its Italian supplier who takes care of both the collection and sorting of textile waste in collaboration with other Italian factories. The post-consumer wool waste is collected from EU & USA.

## Recycling process



The Italian textile industry has had a long tradition of several decades processing fiber-to-fiber recycled wool materials. Therefore when sourcing such textiles Gai-lisva wasn't faced with a big challenge. Post-consumer waste is sorted by colour to avoid the need of decolourization and redyeing. The wool is then cut and shred into fibers and then spun into yarns. 15-20% of virgin cashmere fibers are added to the recycled material to strengthen the quality.

## Production



Production takes place in various factory locations exclusively in Italy. Even being transported from Italy the CO2 outlet is compensated compared to using 100% virgin materials.

## Life cycle



At the moment a take back system is not established but such a platform for pre-owned items is an idea Gai-lisva is considering according to Bettina Jensen the CEO of the brand. Gai-lisvas customers care about sustainability and are aware of their buying patterns e.g. how much they buy, quality and prices. Although this segment of customers in general might only be 20% according to the CEO. When a customer is very happy with a piece of clothing the percentage of usage of the item increases and then lifespan is prolonged.

Gai-lisva began using two recycled materials in 2019. A 100% mechanically recycled cashmere and 100% chemically recycled polyester. Recycled materials cost way more than virgin materials.

It's all about the quality for Gai-lisva and mainly uses natural materials in their products and prefer mono-materials making the recycling process easier. Bettina Jensen the CEO definitely sees the usage of exclusively recycled materials to be the future.





## Collecting & Sorting



## Recycling process



## Production



## Life cycle



**ECONYL®**

**convert**

**Bentzon Carpets**

**ege®**

**Belrey**  
FIBRES

**carpetconcept**

**HAMMER**  
CARPETS

**ECONYL®**

**ege®**

**Fibertex**  
NONWOVENS



**TEKNOLOGISK**  
INSTITUT



**Ege** began their vintage program in 2016 in order to receive post-consumer carpet tiles from their customers preferably locally and resell the ones in good condition. Since carpet tiles haven't been on the market long enough not many have been returned, also when returned many are too damaged to resell. About 30-40% of these can be resold whereas the rest is incinerated.



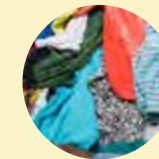
The production value-chain is located in Denmark and Germany in six factories owned by Ege. Four out of six production factories have the ISO 14001 certificate. Each factory has its role and production function such as the two weaving techniques used for the carpets tufting and flatweaving.

Another green characteristic of Ege is their Cradle to Cradle certificate which spreads over five essential areas. Material health, material reutilization, renewable energy, water stewardship and social fairness.



Ege uses a recycled backing called Ecotrust for their products which is made by the company Fibertex and is made of PET bottles. Moreover the recycled nylon yarn, Econyl, made from pre-industrial waste will reach 32% in total by being implemented in a higher number of products. By 2030 this will reach 75%. Ege addresses at the moment 41% own pre-consumer waste to the Italian company Aquafil (Econyl) and are also in an experimentation phase producing with Econyl a recycled yarn made from Ege's post-consumer. Another way Ege recycles its wool yarn waste is by sending it to the company Belrey in Belgium to be recycled mechanically into new yarn.

Researching on making recycling carpets easier is a big part of the Eges' mission. A collaboration between the company Convert and the Technological Institute in Denmark is established for creating a backing material made of their recycled carpets.

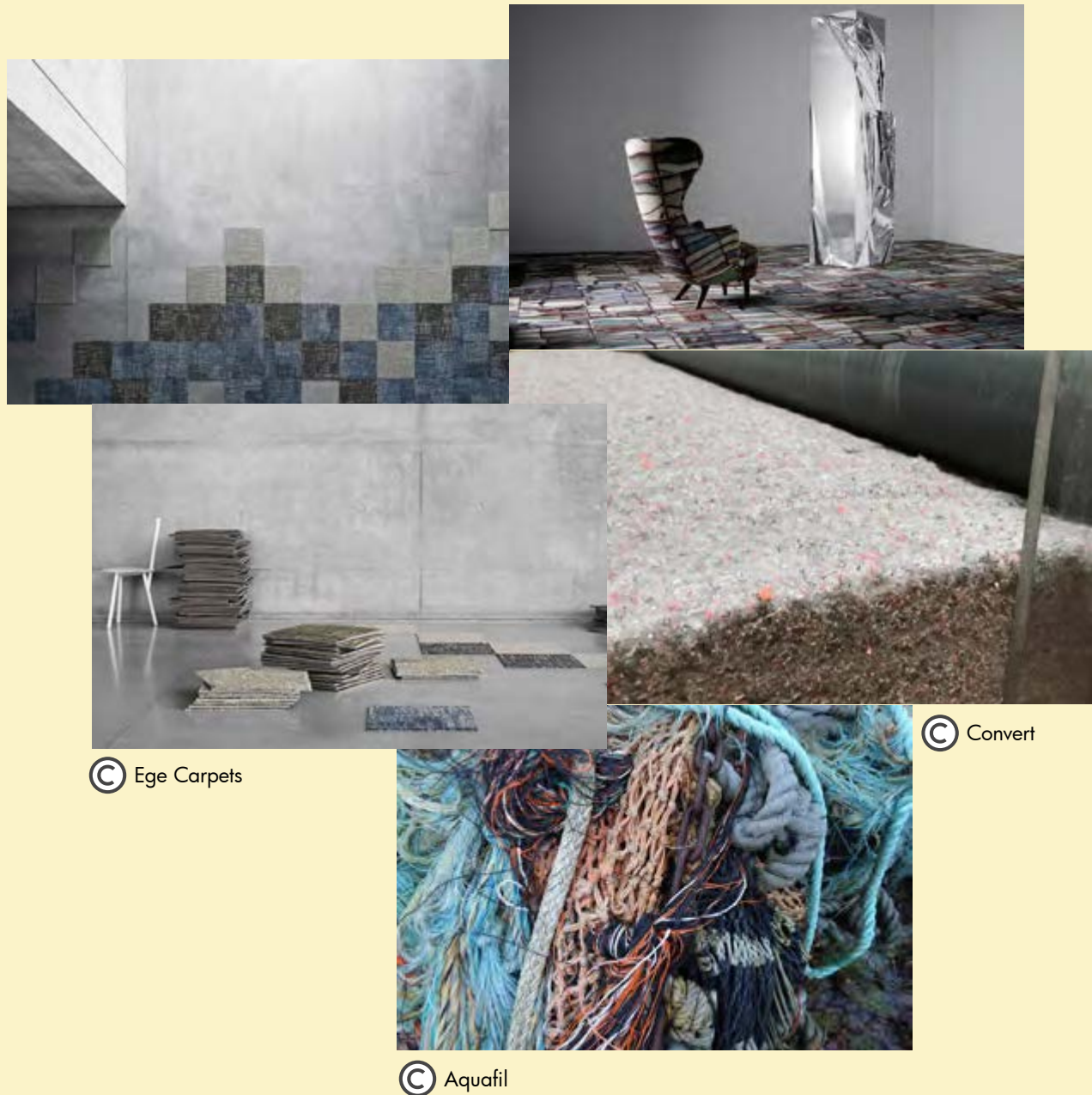


Ege encourages their customers to send used products to local recycling if possible. Solutions are highly needed to be able to disassemble carpets in an easier and more efficient way in the future.



The two biggest challenges Ege is facing are in the production and design phases. Ideally in the future a carpet will be designed so it can be easily recycled right after use. Attempts of 100% polyester carpets have been made. When a product is mono-material it is ideal for recycling.

According to the CSR director Henrik Schmidt the fashion industry might have more advantages of becoming circular since not as many materials and components are involved in one piece of clothing. A carpet design can contain up to 200 components because of the many safety rules demanded.



© Ege Carpets

© Convert

© Aquafil

## Going forward

When the use phase for a textile is over and it is not able to be reused in its original form, recycling it could be the next step. This publication has shed light on fiber to fiber recycling processes showing that the industry is getting closer to a solution on the challenges of the future, however there are challenges the textile industry needs to tackle on the way. With time more sustainable materials might replace the complex textile compositions of today, new technologies will emerge, chemical processes will improve, and further innovative collaborations will happen making fiber to fiber recycling more and more easy, environmentally beneficial and economically profitable.

It is debatable what the next step for textile recycling should be, however it is definite that the textile mills are facing challenges that the entire industry needs to address if we are to promote a circular textile future. How do we most efficiently develop the industry to become more circular? Are there factors indicating that textile recycling within upholstery and interior are easier than recycling wearables and clothes or is it the other way around? How can the industry and the systems around it create opportunities for the industry to transform fully? These are questions that we at Lifestyle & Design Cluster continuously work with and we will keep you updated – Please stay tuned!



Lifestyle & Design Cluster

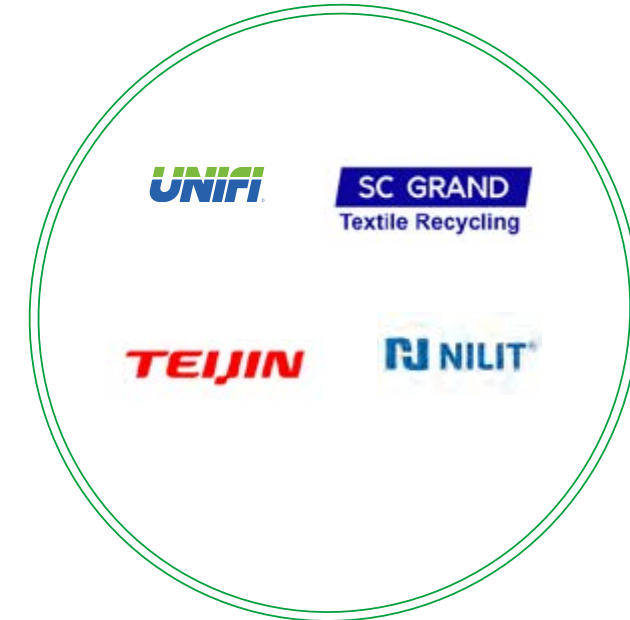
Textile plants outside EU



P Pilot



O Operational



C Commercial





**WHAT:** Engineered fiber from post-consumer clothing waste

**PROCESS:** Mechanical & NuCyl tech (extracting molecular)

**RESULT:** Yarn & Fabric

**CUSTOMERS:** Adidas, Stella McCartney



**WHAT:** Post-consumer waste clothing & textiles (polycotton)

**PROCESS:** Chemical

**RESULT:** PES pellets & yarn for fashion items

**AWARDS:** H&M Global Change Award 2016



**WHAT:** PET waste

**PROCESS:** Thermal & mechanical, four REPREEVE products. Nylon 6 from pre-consumer waste: tents, socks, backpacks

**RESULT:** Fashion & home textiles. Tops, socks, outdoor, automotive, home (curtains to carpet)

**CUSTOMERS:** Lindex, Nike, Adidas, H&M



**WHAT:**

1. Texloop (post-consumer waste)
2. Orbital Hybrid yarn
3. Agraloop biofiber (agriculture waste)

**PROCESS:** Texloop is created from post-consumer waste both natural & synthetic fibers (polycotton, CO, PES, Viscose) with some % of organic virgin cotton

**RESULT:** Fabric for fashion

**AWARDS:** H&M Global Change Award 2018



**WHAT:** BlockTexx is a clean technology company that recovers polyester and cellulose from textiles and clothing. Feedstock supply: Pre- and post-consumer (consumer, industrial, commercial)

**PROCESS:** Chemical. Feedstock: Polycotton, Polyester/MMC, Polyester, Cotton, MMC

**CUSTOMERS:** Work with Australian and International brands

**STATUS:** Pilot facility with a commercial scale plant due Q4 2020



**WHAT:** TEIJIN makes it possible to separate and eliminate additives and colorants not only from PET bottles but also from other polyester products. PET bottles, post-consumer, min. 80% pes, natural fibers too

**PROCESS:** Chemical, no closed loop since feedstock isn't only textile waste

**RESULT:** ECO CIRCLE fibers, 10-20% more expensive than virgin, reduction 84% in energy consumption, Low environmental impact reduction effect of CO2 emissions



**WHAT:** Pre-consumer & post-consumer waste

**PROCESS:** Mechanical, 0% water waste, 0% chemical waste, automated colour sorting system (9 colours) where machines can process up to 3 tonnes per day. Addition of virgin materials is needed to spin a strong and high-quality yarn.

**RESULT:** Yarns for fashion

**CUSTOMERS:** Big players of the fashion industry

**STATUS:** Commercial