

# Recycled Cotton Fibres in Technical and Clothing Applications

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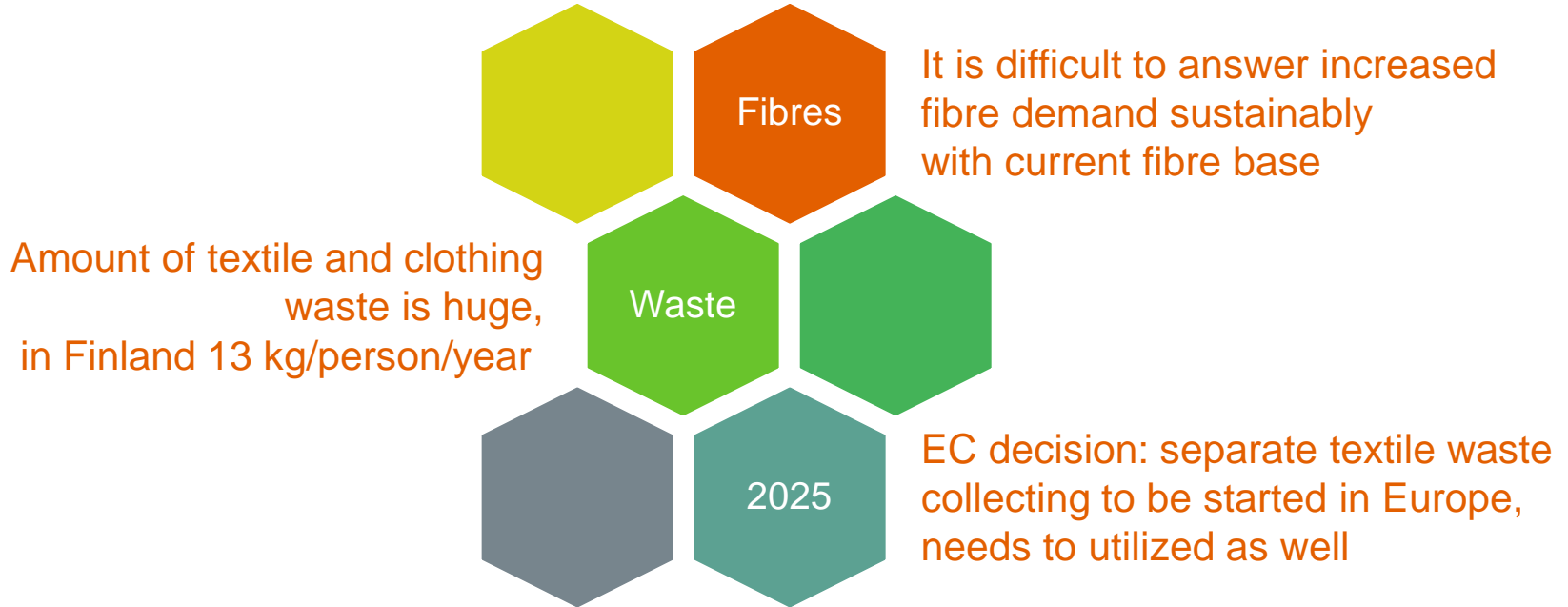


PURE WASTE  
100% RECYCLED TEXTILES

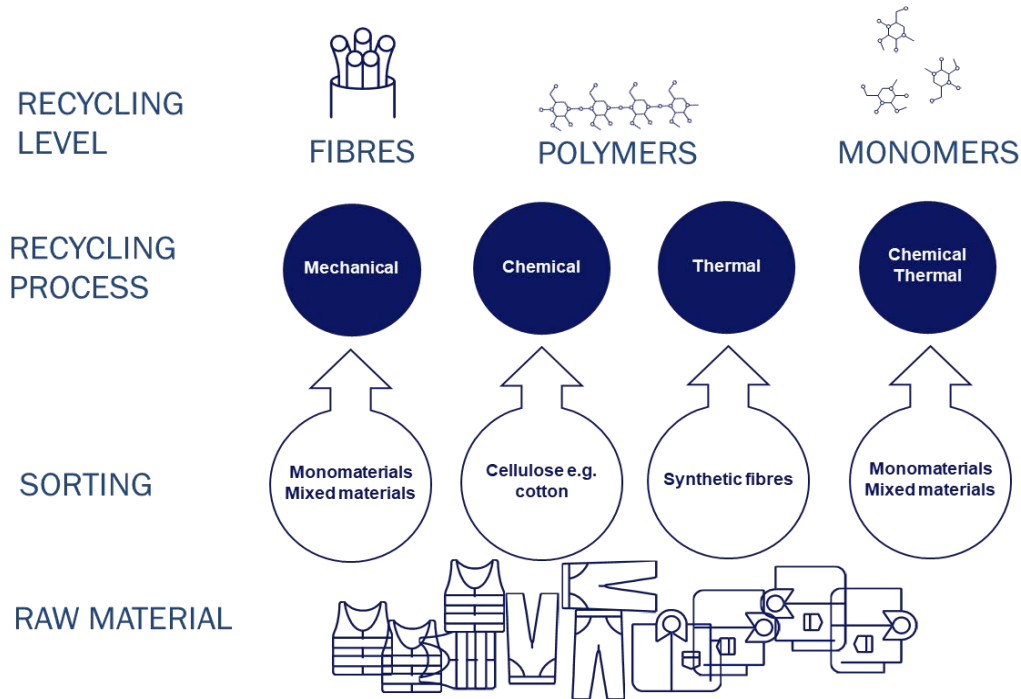
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# Motivation



# Recycling methods



Heikkilä P. *et al.*, *Telaketju - Towards Circularity of Textiles*, VTT Research Report, VTT-R-00062-19,  
Available: <https://cris.vtt.fi/en/publications/telaketju-towards-circularity-of-textiles>

## Different textile fractions

Type	Pre-consumer	Post-consumer
Origin	Industry	Users
Composition	Known	Un-known
Cleanliness	Clean	Un-known
Quality	Good	Lowered

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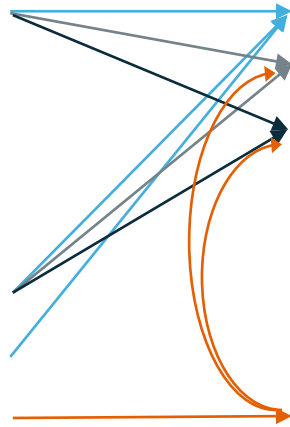
# Materials and Methods

## Pre-consumer cotton

- Industrial cutting waste

## Post-consumer cotton

- Sorted and opened
- Dust-like opening side-stream
- Sorted and grinded



## Mechanical recycling

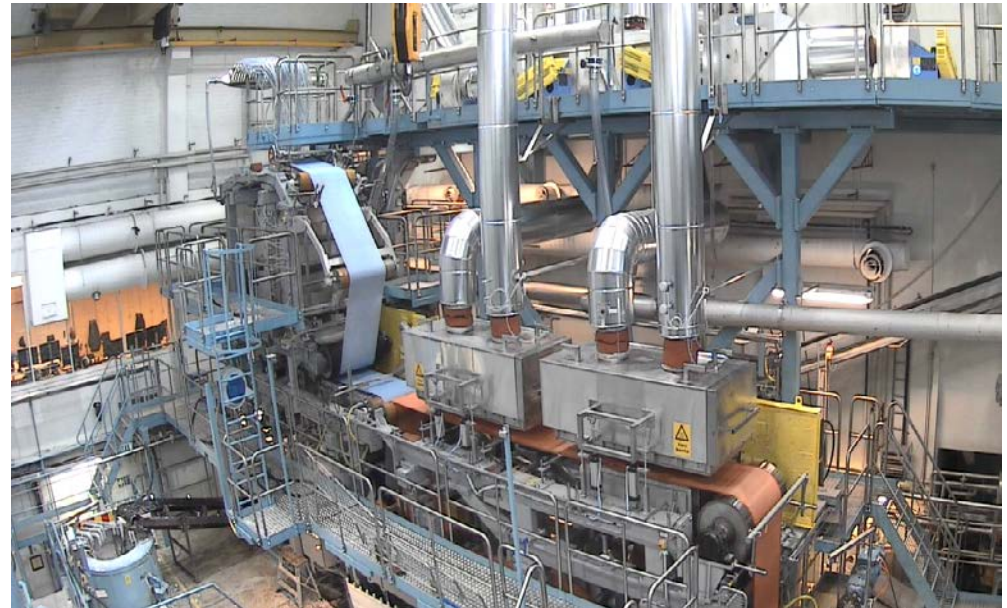
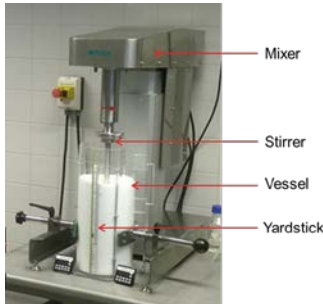
- Nonwovens / foam laying
- Yarns / open-end spinning
- Yarns / ring-spinning

## Chemical recycling

- Fibres / cellulose carbamate technology and wet-spinning

# Foam laying - Method

- Like wet-laying, but aqueous foam instead of water as transport media → **less water & less drying**
- Typical process
  1. Surfactants and water mixed into foam
  2. Fibres added
  3. Foam transferred onto wire for removal of water



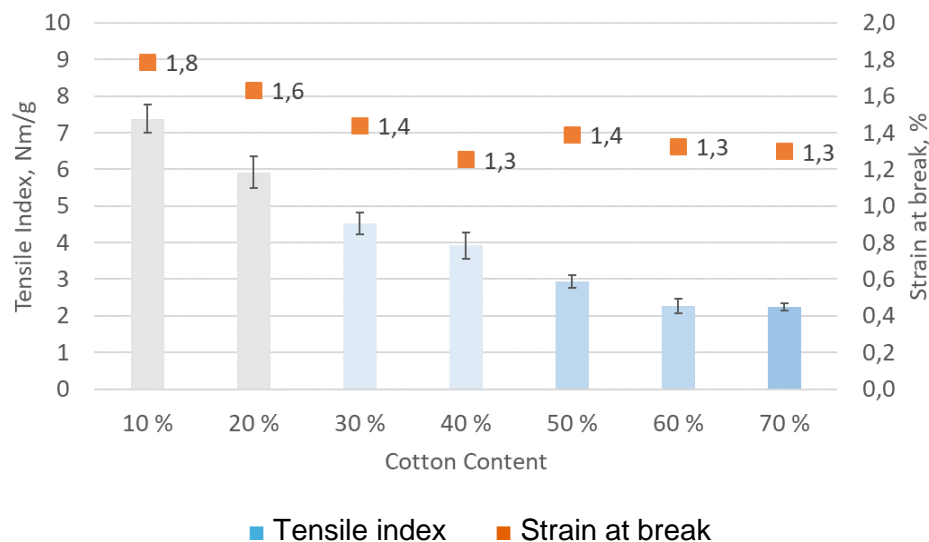


# Foam laying - Pilot scale

## Dust-like recycled post-consumer cotton mixed with pulp

Cotton content from 10 % to 70 %

Targeted weight 100 g/m<sup>2</sup>



Heikkilä P. *et al.*, *Telaketju - Towards Circularity of Textiles*, VTT Research Report, VTT-R-00062-19,  
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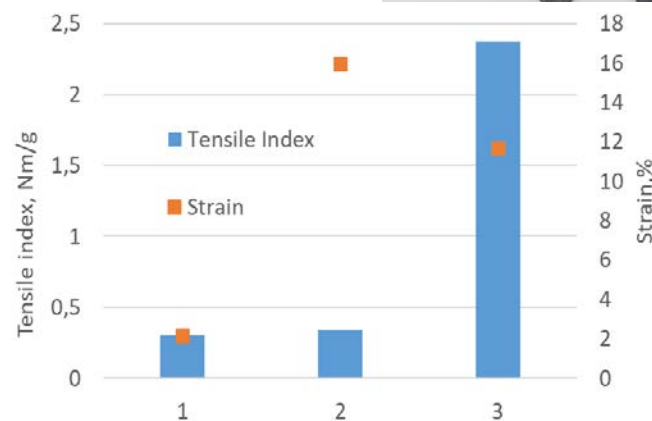
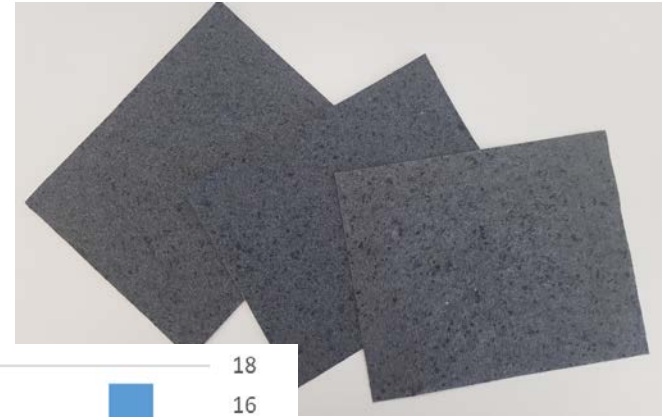
# Foam laying - Lab scale

## Pre-consumer cotton mixed with other fibres

Mixtures of following fibres:

- Cellulose pulp
- Bi-component binder fibres
- Lyocell

No	Fibres	Weight (g/m <sup>2</sup> )
1	r-CO 70 % / pulp 30 %	100
2	r-CO 90 % / bico 10 %	70
3	r-CO 45 % / lyocell 45 % / bico 10 %	70



NordicBio project – unreported data

# Ring spinning - Lab scale

## Post-consumer cotton mixed with virgin and recycled fibres

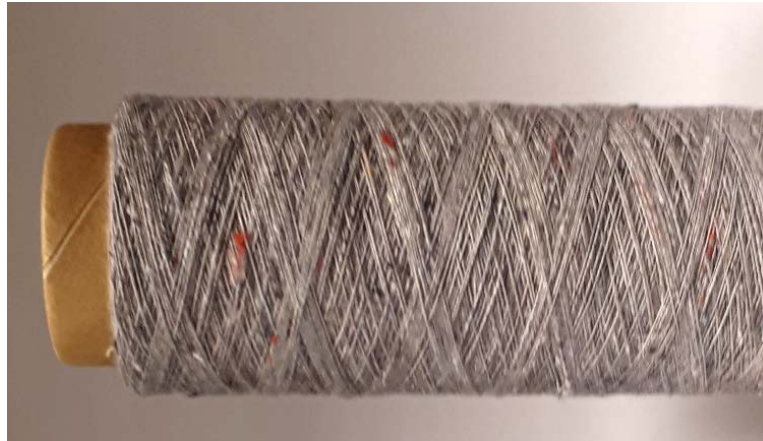
Cotton opened 5 or 6 times, mixed with virgin cotton & viscose, and post-consumer r-PET

Fibre composition	Outcome
100 % r-CO	Sliver was formed, but spinning required blending (with used machine)
50 % r-CO (6) / 50 % CO	A yarn was difficult to spin, resulted only small and weak samples
50 % r-CO (6) / 50 % CV	Spinning worked well and resulted yarn (88 tex and 650 twists/meter) – see next slide The yarn was test knitted, but it was too thick for a lab scale knitting machine
30 % r-CO (5) / 70% CV	Spinning worked well and resulted yarn (66 tex, 650 twists/meter) The yarn suited well for knitting – see next slide
40 % r-CO (5) / 40 % r-PET / 20 % CV	Roving was formed, but it was uneven and yarn spinning was not possible

Heikkilä P. *et al.*, *Telaketju - Towards Circularity of Textiles*, VTT Research Report, VTT-R-00062-19,  
Available: <https://cris.vtt.fi/en/publications/telaketju-towards-circularity-of-textiles>

# Ring spinning - Lab scale

Post-consumer cotton mixed with virgin and recycled fibres



50 % r-CO (6) / 50 % virgin CV

Yarn



30 % r-CO (5) / 70% virgin CV

Yarn and knitted material

Heikkilä P. *et al.*, *Telaketju - Towards Circularity of Textiles*, VTT Research Report, VTT-R-00062-19,  
Available: <https://cris.vtt.fi/en/publications/telaketju-towards-circularity-of-textiles>

# Ring spinning - Pilot & industrial scale

## Mixture of chemically and mechanically recycled cotton

Chemically recycled cotton via cellulose carbamate technology in pilot scale

Mixed 1:1 ratio with pre-consumer cotton for ring spinning and knitting in industrial scale

Designer dress by Anna Ruohonen

Yarn				Fabric grammage
Count	Tensile strength	Breaking tenacity	Elongation	
39 tex	3 N	0.08 N/tex	6.7 %	291 g/m <sup>2</sup>



Heikkilä P. *et al.*, The Relooping Fashion Initiative, VTT Research Report, VTT-R-01703-18,  
Available: <https://vtt.pure.elsevier.com/en/publications/the-relooping-fashion-initiative>

# Open-end spinning - Industrial scale

## Mixture of post- & pre-consumer cotton and r-PET

Post-consumer cotton (20 %),  
pre-consumer cotton (40 %) and  
recycled polyester from bottles, r-PET (40 %)

Yarn and fabric quality did not deviate from typical commercial OE yarns

- Yarn count 20.3 Ne (30 tex), 15.4 twists per inch and yarn Lea strength was 66.57 lbs
- Knitted fabric shrinkage 2.8 % and 2.3 % (length and width), and spirality of 0.5% after one wash

➤ **Material ready for commercialization**



Pure Waste Textiles, unreported data

# Summary & Conclusion

- Separate collection of textile waste to be started in EU member states by 2025 – we can expect to have recycling targets e.g. for 2030
- We have demonstrated recycling of various types of both pre- and post-consumer cotton using processes from lab to pilot and industrial scale
- Recycled cotton can be used for making nonwovens and yarns – application possibilities vary from technical to clothing & fashion
- Mechanical recycling processing – shedding and opening – reduce fibre length while chemical recycling restores it
- Depending on fibre and its quality there are different processes to be selected in order to get desired material properties and, thus, enabling using recycled cotton in high-value products

# Future Prospects

- Knowing quality is essential in selecting best technology for obtaining highest value
  - Standardization needed
- Sorting process is essential for mixed post-consumer materials, but not needed for known batches e.g. industrial side streams
  - Keeping different textile waste fractions separate, if that affects their suitability for recycled products
- Hygiene might be an issue from textile waste coming from consumers
  - Cleaning process to enable post-consumer from private consumers to be used e.g. in skin contact, personal care and hospital applications



# Further Work

## Telaketju 2 BF project

National Finnish action **building circular textile ecosystem** from collection & sorting to recycling as well as new circular business models.

Coordinated by VTT, 3 research partners, 5 company projects including Pure Waste Textiles, over 20 companies co-funding the project with Business Finland.

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

## NordicBio project

Swedish-Finnish action aiming for the development of new solutions for replacing synthetic disposable products with bio- and circular economy materials in hospital textile applications.

VTT develops **cleaning process** and **foam laid materials**.

Pure Waste develops **yarns & fabrics**  
Funding from Vinnova and Business Finland  
<http://www.mynewsdesk.com/se/innovatum/pressreleases/nordicbio-creating-circular-textiles-for-nordic-healthcare-2844024>

# Acknowledgements

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- *Telaketju 2 BF* -project, 2019-2021

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