

**Innovative**  
**by** *nature*

## **Environmental Responsibility of the Man-Made-Cellulosic Fiber Value Chain**

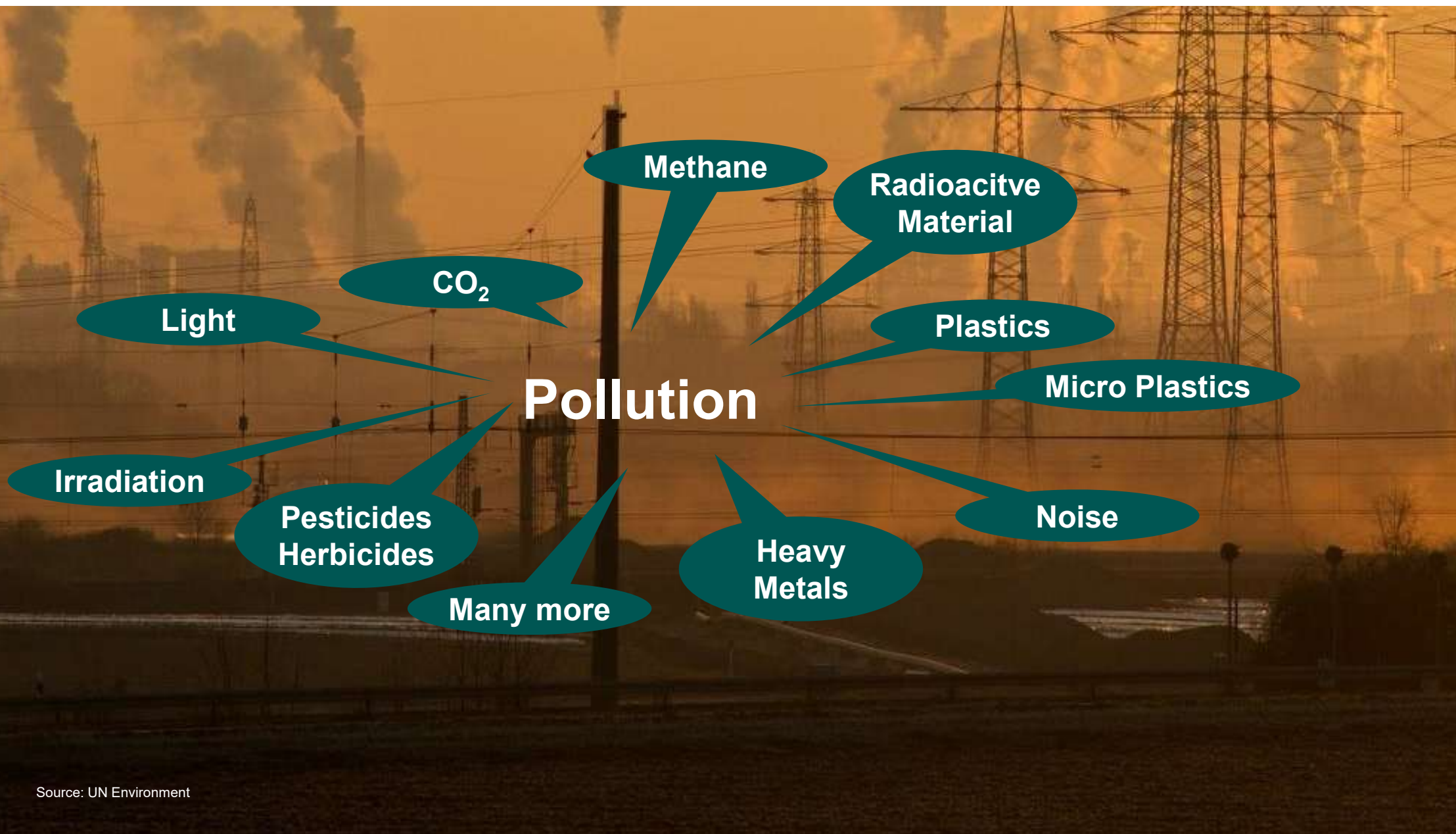
Gabriele Schild, [g.schild@lenzing.com](mailto:g.schild@lenzing.com)  
Cellulose Workshop 2020-11-17



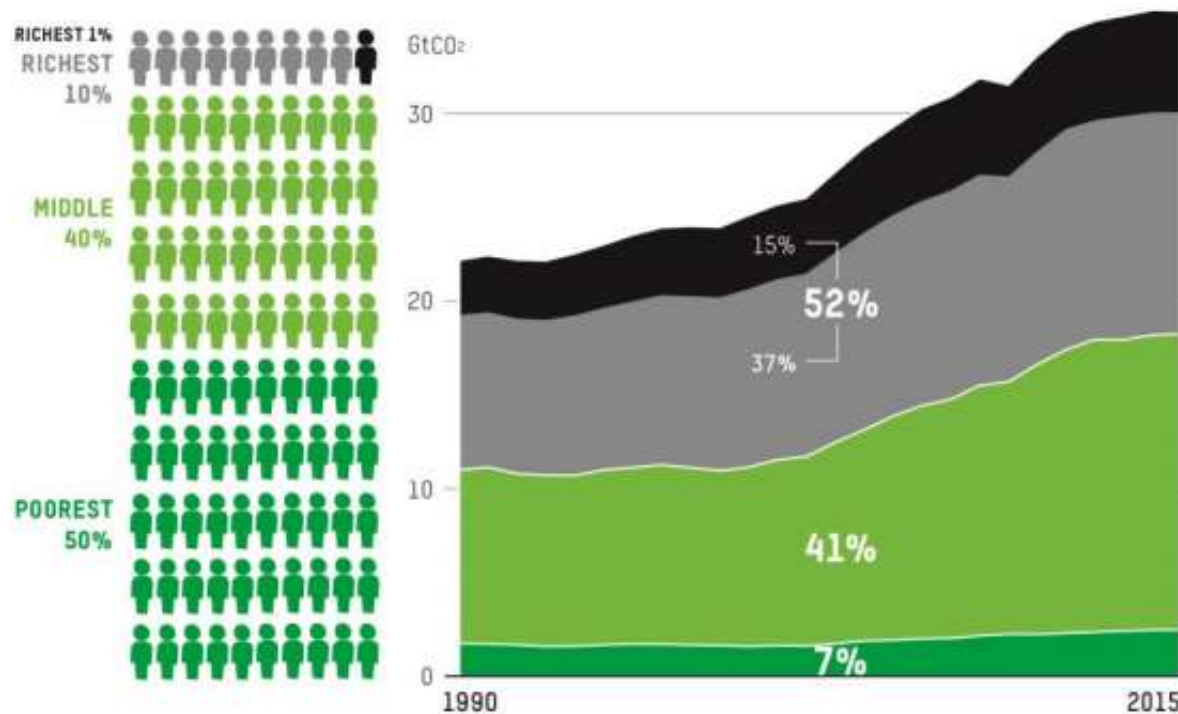
**We have a problem .....**

Source: UN Environment





# Highest Income Groups Show Highest Emission



## Top 10 %

- CO<sub>2</sub>-emission > 50 %
- Annual salary ≥ 30,000 €

# CO<sub>2</sub>-Consumption for Textiles

## Global apparel and footwear

- About 10% global CO<sub>2</sub>-emission
- Production almost doubled from 2000 to 2015



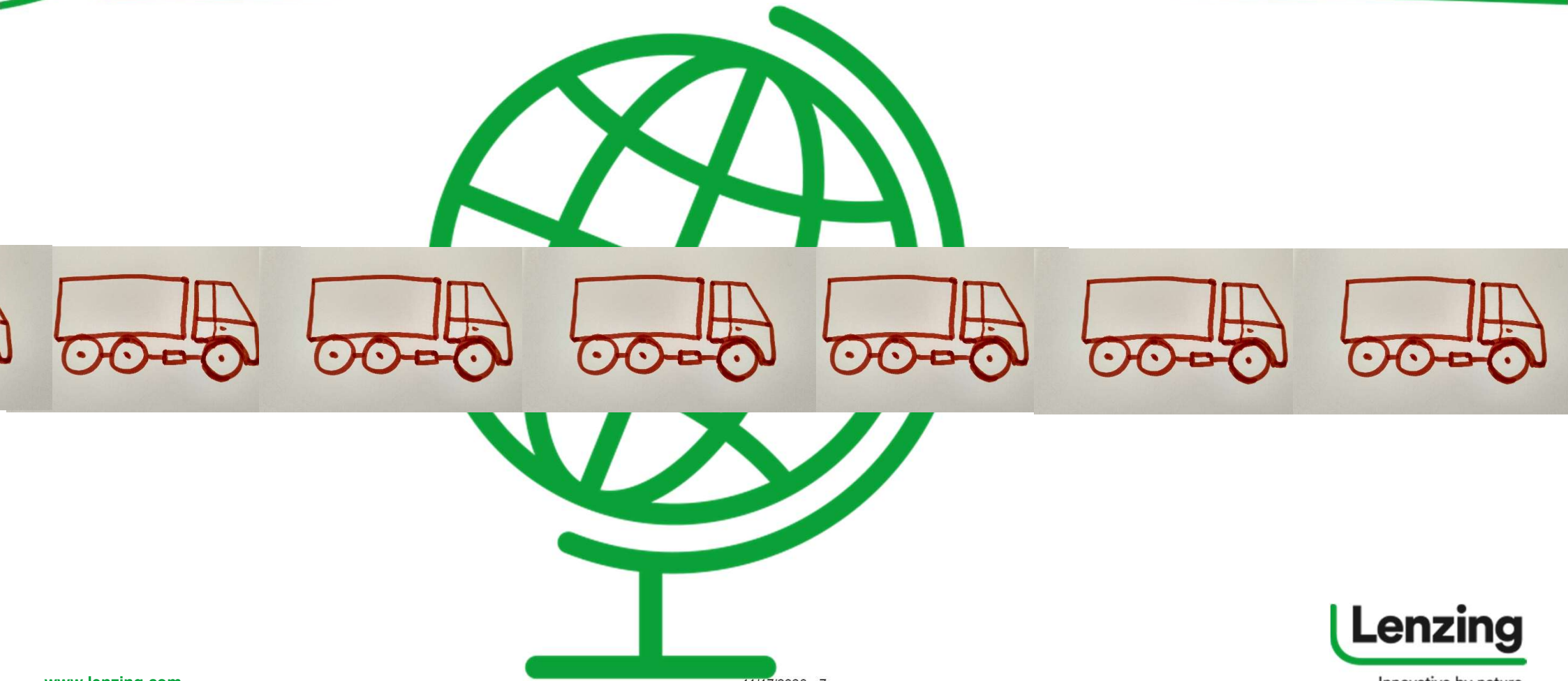
## Total Fashion Waste in 2030

☐ 148,000 tons

☐ 1.48 million tons

☒ 148 million tons

# Trucks 2.5 x Around the Earth



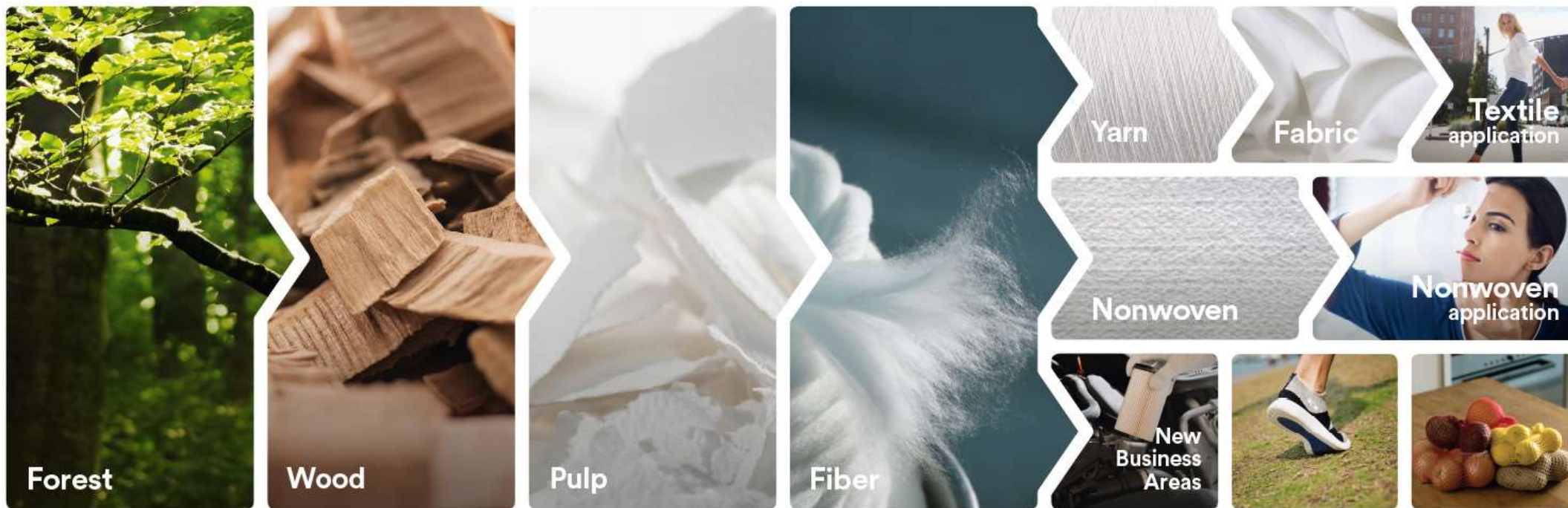
## Contribute to the Solution



**Responsibility**



# LENZING™ Fibers



# The Lenzing Group 2019

- Group revenue: 2.11 billion €
- R&D: 53.2 million €
- Employees: 7,036
- Dissolving pulp: 595,000 t
- Viscose, modal, lyocell: 1,045,000 t



# Production Sites of the Lenzing Group



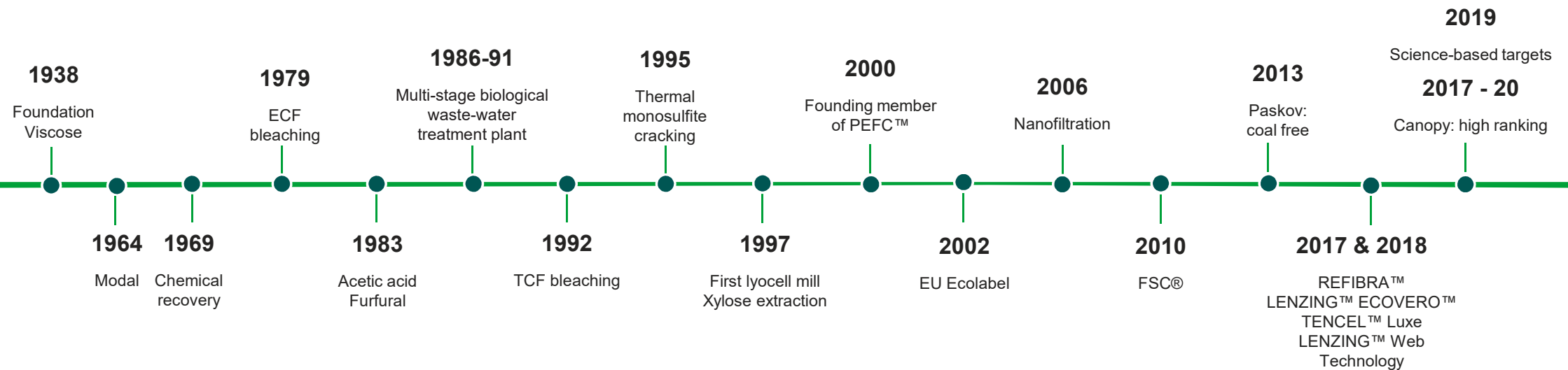


# Highly Sensitive Region

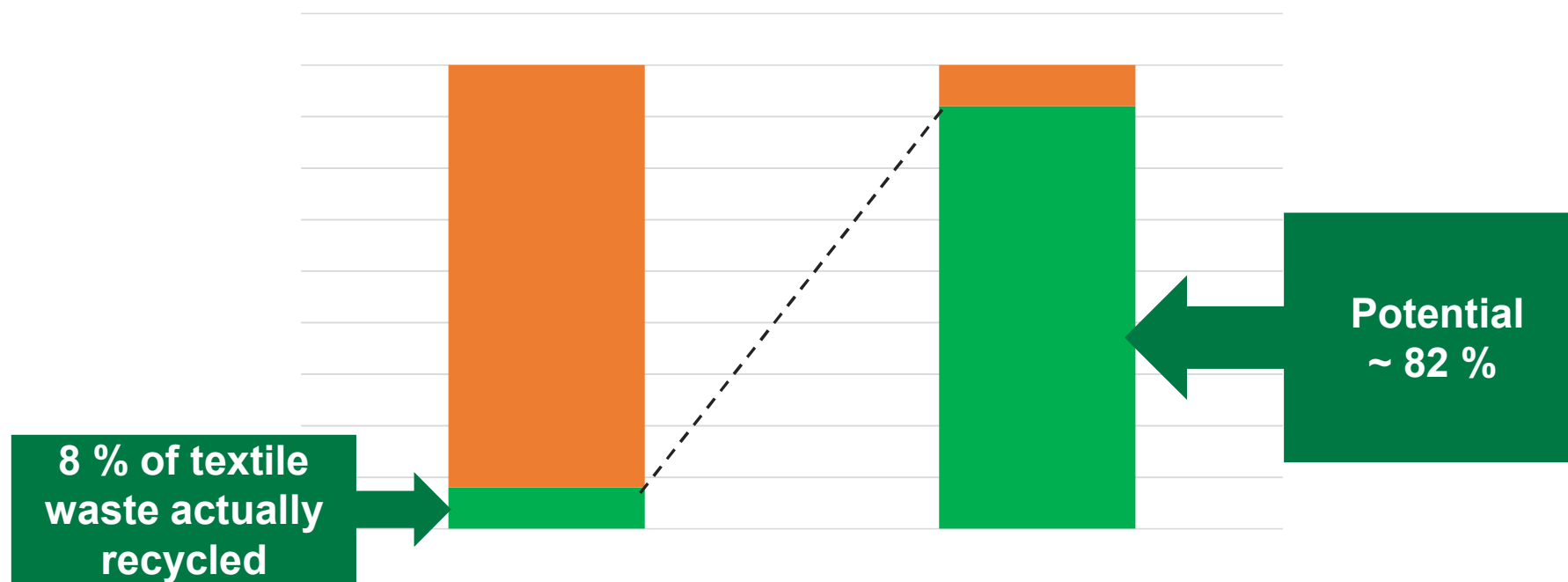




# Milestones of Industrial Responsibility



# High Potential of Textile Recycling



# Lyocell Fiber with Recycled Cotton

 **Tencel™**  
Feels so right



 **Tencel™**  
Feels so right

X

 **REFIBRA™**  
technology



# Recycling of Cotton Waste

Property	TENCEL™ x REFIBRA™
Titer [dtex]	1.7
Tenacity cond. [cN/tex]	33
Elongation cond. [%]	13
Tenacity wet [cN/tex]	27
Elongation wet [%]	17

- Constant high quality since 2017
- Suitable for all common spinning technologies and applications
- Fiber properties like virgin lyocell fibers with high brightness



## Used Textiles Increase Rejects



# Successful Use of Post- and Pre-Consumer Waste

Property	Mill trial	REFIBRA™ Reference
Pre-consumer [%]	25 - 20	30
Post-consumer [%]	5 - 10	0
Pulp [%]	70	70
Titer [dtex]	1.7	1.7
Tenacity [cN/tex]	36	33
Elongation [%]	13.6	13

- Successful mill trial with pre- and post-consumer cotton waste
- High strength properties
- Processing of 50 % post-consumer waste under development

# Recycling of Lyocell Fibers

Example	REFIBRA™ fiber [%]	Pulp [%]	Titer [dtex]	Tenacity [cN/tex]	Elongation [%]
A	100	0	1.25	34.2	10.7
B	20	80	1.32	33.9	12.1
Reference	0	100	1.26	33.5	11.8

- Successful recycling of lyocell fibers in lab / pilot scale
- Cellulose II processed in the lyocell process
- Fiber qualities like virgin lyocell fibers

# Recycling by the Lyocell Process

- Environmentally friendly lyocell technology + recycling of cotton scraps:
  - 30% recycled pre-consumer cotton
  - wood from FSC® certified (FSC-C041246) or controlled sources
- Virgin quality fibers with high brightness
- Constant high quality since 2017
- Full traceability
- STANDARD 100 by OEKO-TEX® and others
- Multiple applications
- Recycling of post-consumer waste
- Recycling of lyocell fibers

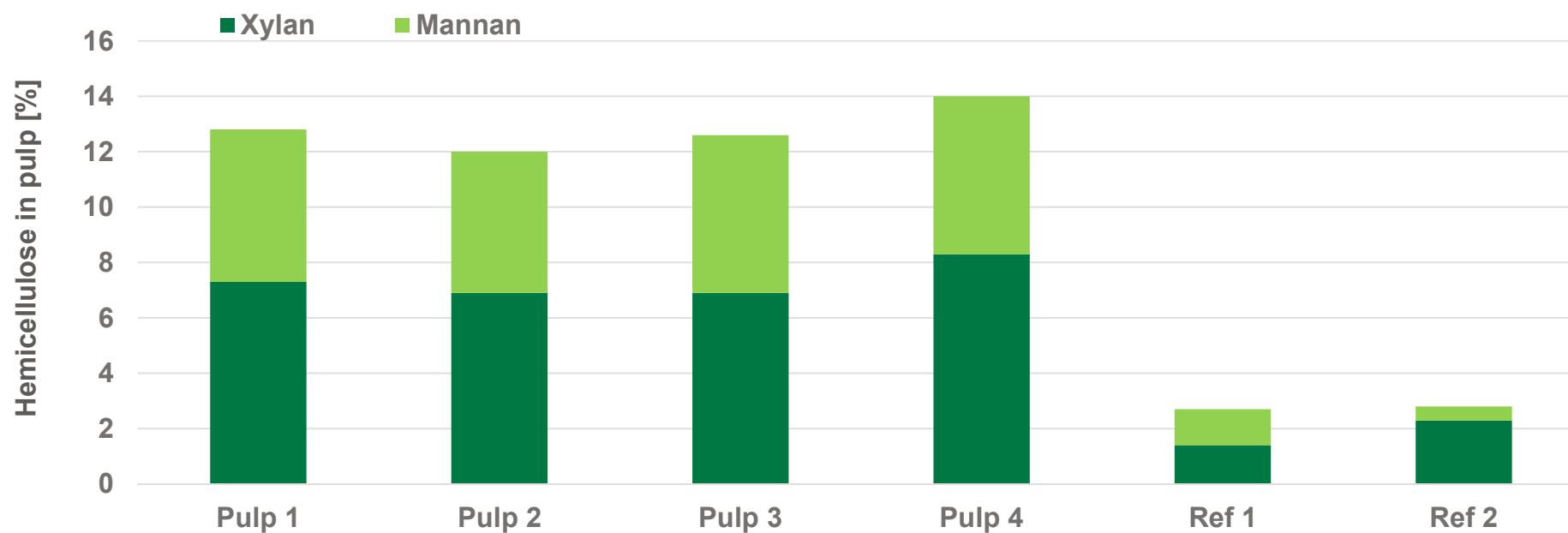


## Resource Efficiency

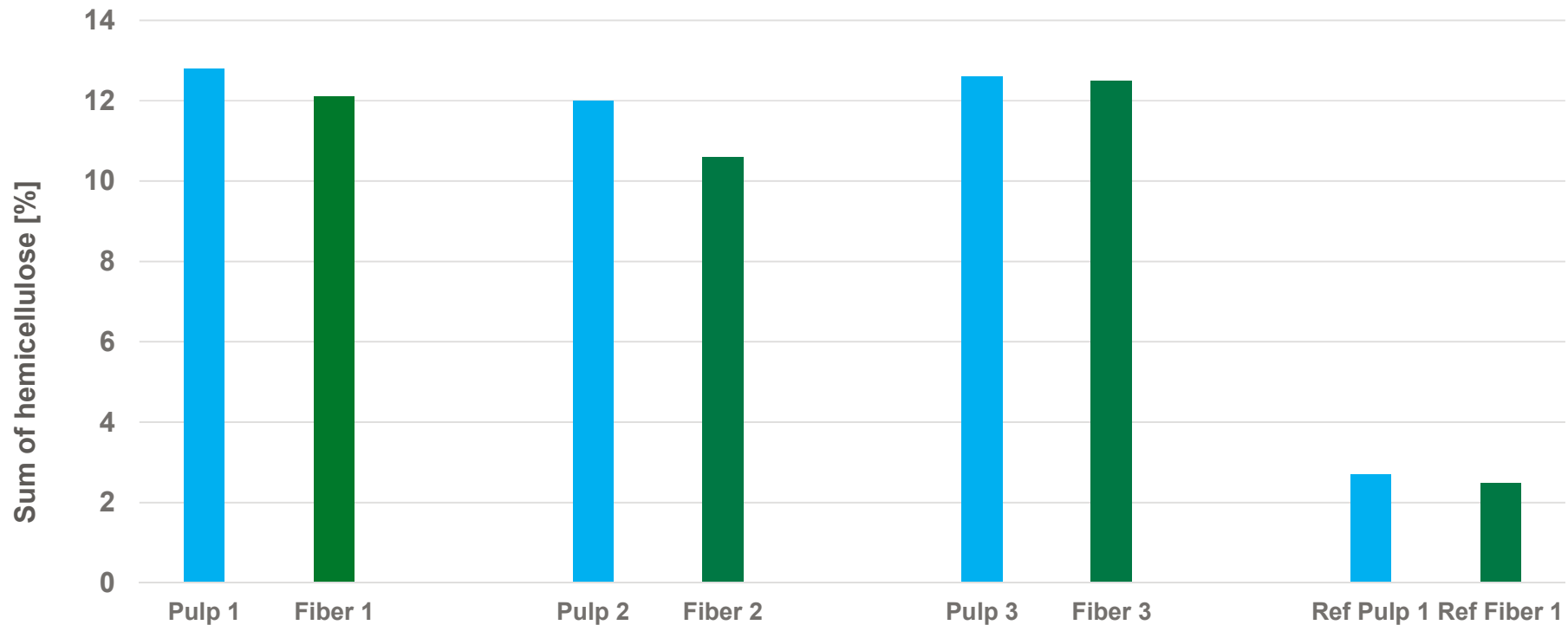
Lyocell fibers with a high mannan and xylan content



# Market Pulps with High Hemi Content

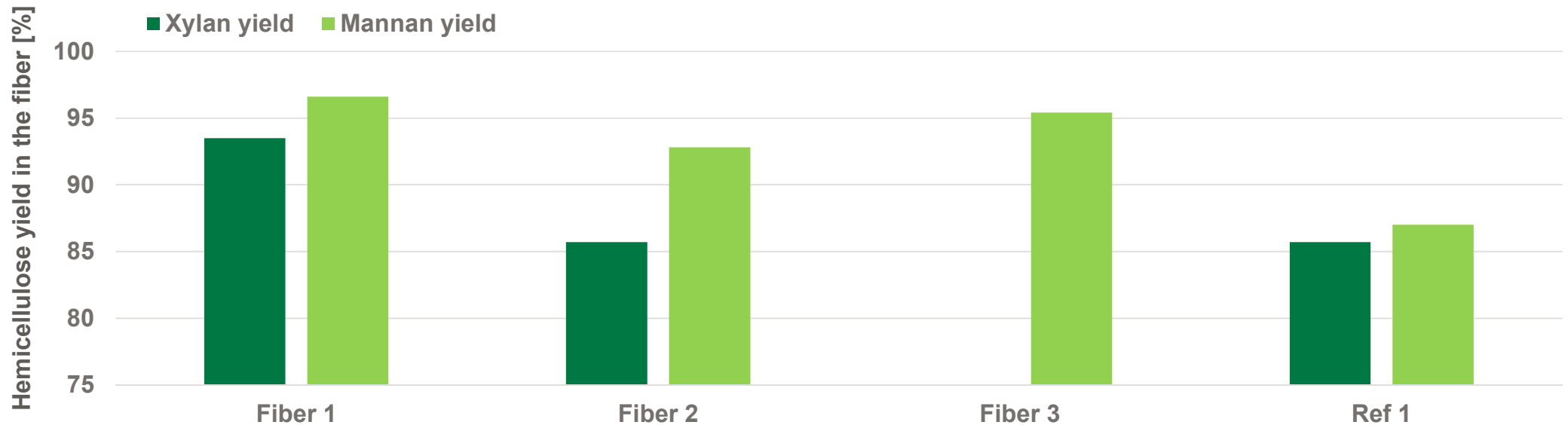


# Hemicelluloses Transferred into the Product



- High proportion of hemis transferred into the lyocell fiber

## Relative Polymer Yield



- Stability of polymers in the lyocell process:  
cellulose > mannan > xylan
- Mannan from pulps without first acidic process step  
more stable

## Sufficient Dry Strength Properties

- Tensile strength and elongation suffer to a minor extent
- But strength properties are still at a high level as known for lyocell fibers
- Hemicelluloses show lower molecular weight => hinder cross linking of cellulose chains => decrease strength



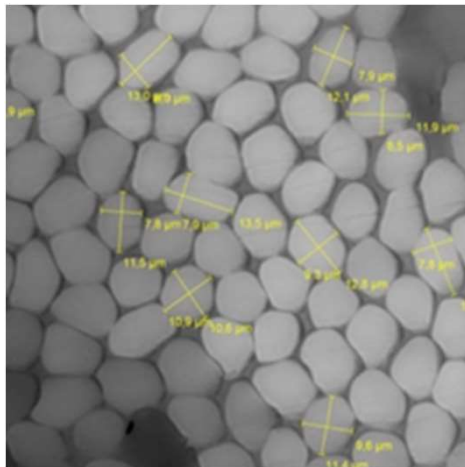
## Positive Effects on Wet Elongation

- Wet elongation > dry elongation: swelling in water increases the mobility of the amorphous regions
- Hemi swell more intens => wet elongation increases over proportionally with higher hemi content

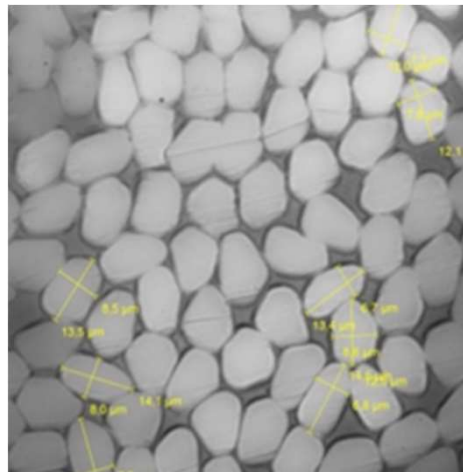
## Lower Crystallinity and Higher Water Adsorption

	Fiber 4	Fiber 4	Fiber Ref 2	Fiber Ref 2
Pulp	Pulp 4		Ref 2	
Titer [dtex]	1.3	1.8	1.3	1.8
Sum of hemi [%]	12.5	12.6	2.1	2.3
CrI [%]	37	40	44	47
WRV [%]	82.8	82.1	69.6	65.3

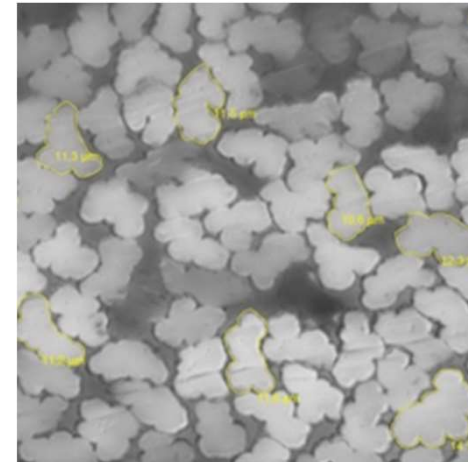
## More Circular Fiber Cross Section



Hemi rich lyocell fiber

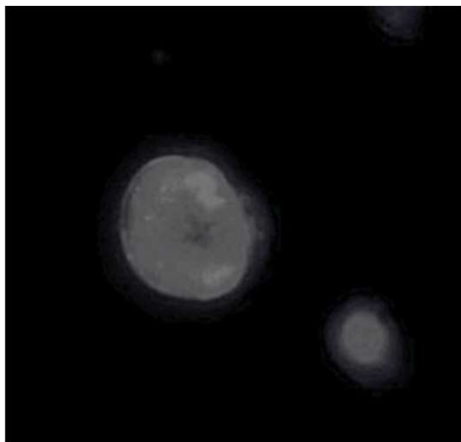
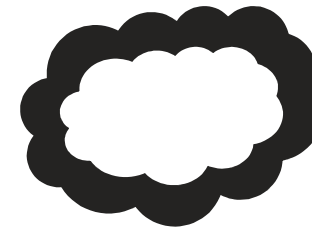
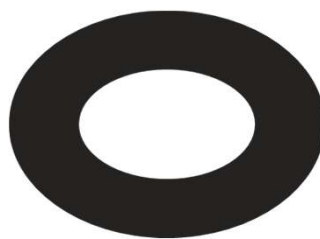
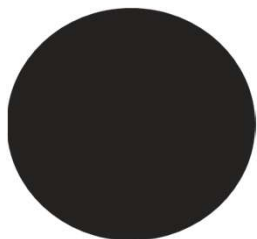


Standard lyocell fiber



Standard viscose fiber

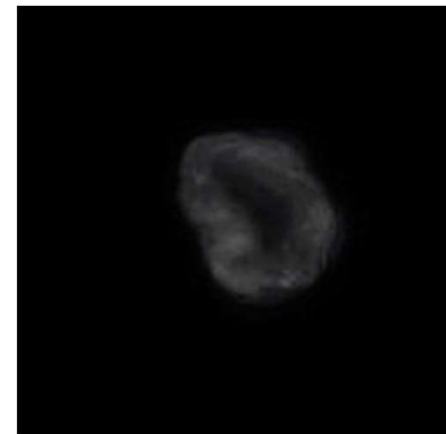
## More Homogeneous Pore Structure



Hemi rich lyocell fiber



Standard lyocell fiber




Standard viscose fiber

# Lyocell Fibers with High Hemicellulose Content

- Increased resource efficiency and sustainability
- Successful mill trials for lyocell fibers with high hemi-content
- Fiber strength at comparable level
- Possibility to produce controlled fiber properties by varying the hemi-content:
  - Stability of polymers: cellulose > mannan > xylan
  - Mannan from a first alkaline production step very stable
  - Hemicelluloses hinder crystallization
  - Increased uptake of water
  - More circular shape with a more homogeneous pore structure

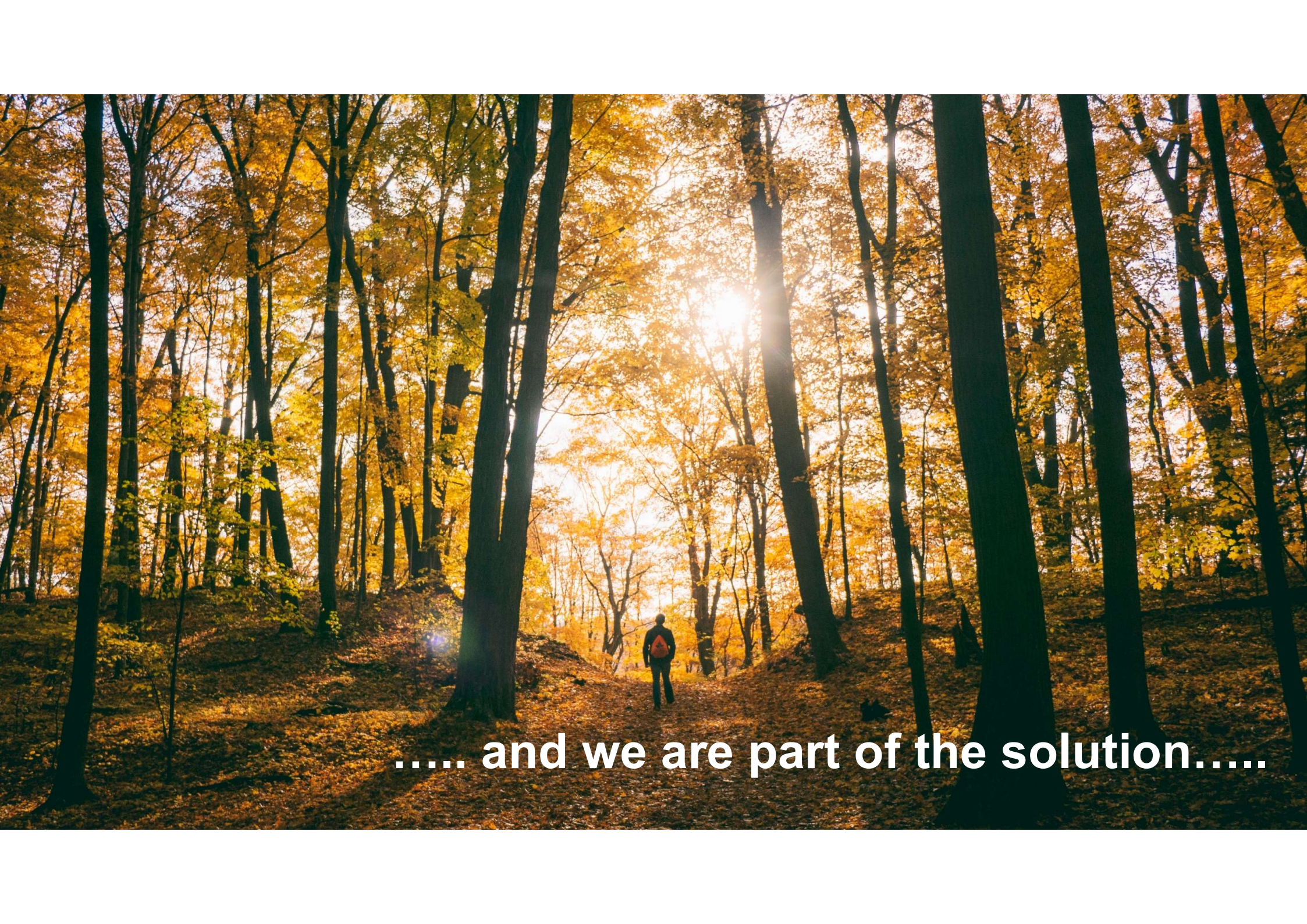




**We have a problem .....**

Source: UN Environment





**..... and we are part of the solution.....**



# Taking Responsibility

- ✓ Starting to take actions as industry at a very early stage
- ✓ Permanent engagement for sustainability, high resource efficiency, and circularity
- ✓ Canopy 2020: highest possible ranking!
- ✓ R&D achievements for the lyocell process
  - ✓ Recycling of pre- and post-consumer cotton waste
  - ✓ Recycling of lyocell fibers
  - ✓ Use of hemicelluloses as fiber-forming polymers



**Our commitment:  
Being carbon  
neutral by 2050**

Thank You

**for your  
attention!**

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