telavalue

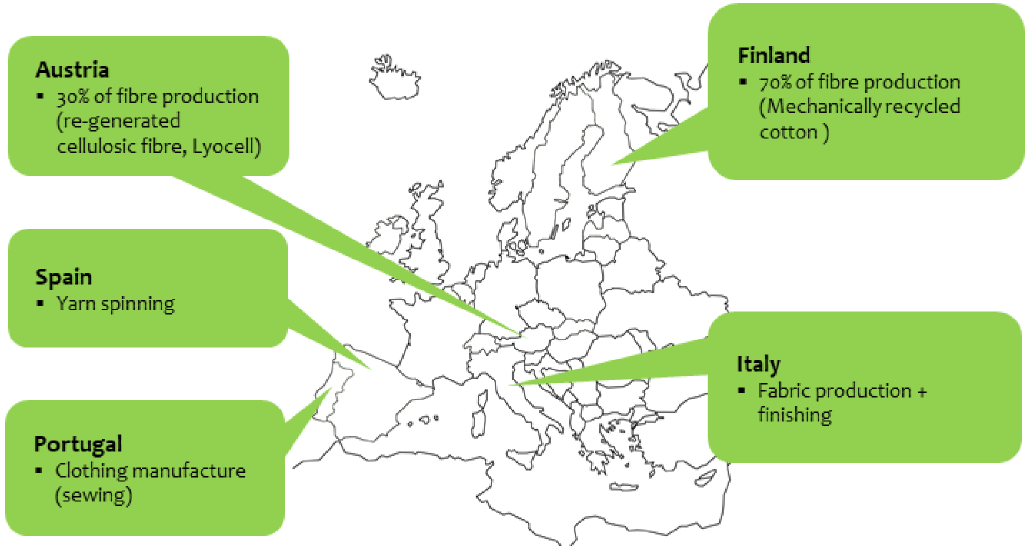
WP1 CIRCULAR VALUE CHAINS

T1.1 IMPACTS STUDIES: ENVIRONMENTAL IMPACTS
- Comparing the current global value chain with a potential future circular value chain

CASE: GREY SWEATSHIRT

- Weight 305 g
- Made of 70 % cotton and 30 % PET (linear case) in Asia
- Made of 70 % mechanically recycled cotton and 30 % Lyocell (circular case) in Europe

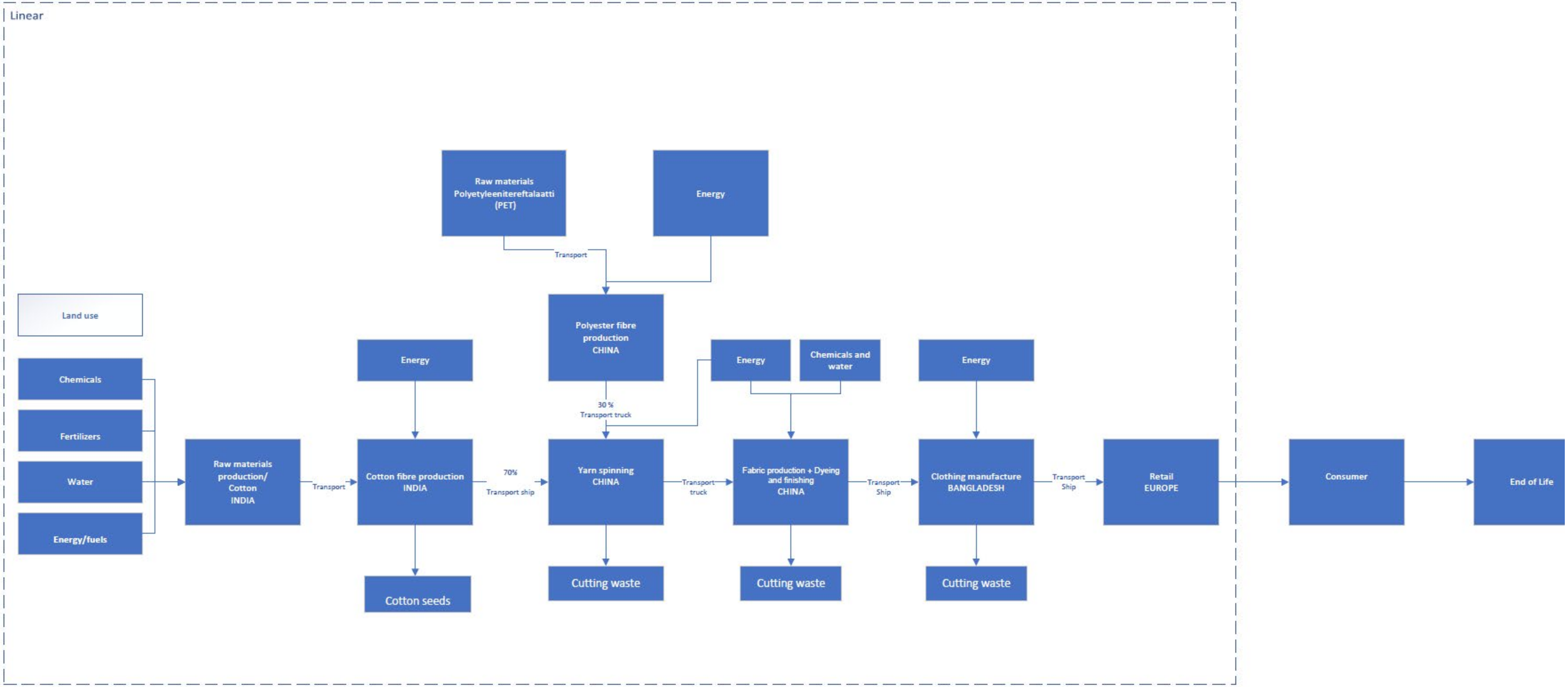
Picture 1.
Processes of the product chain in the current situation.



Picture 2.
Processes of the product chain in a potential future circular version.

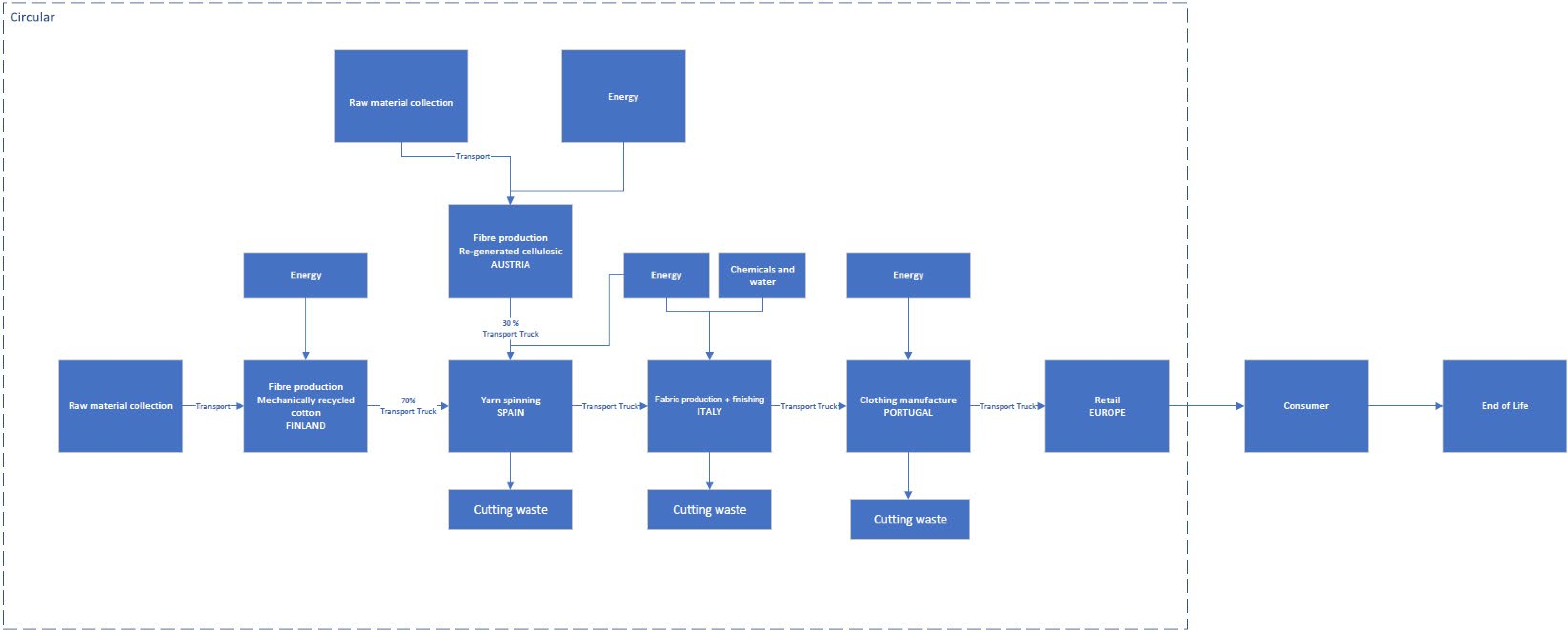
LINEAR VALUE CHAIN

The assumption of the current global value chain is presented below.
The entire value chain should be taken into account when evaluating the environmental impacts of the value chain.
In the following slides, the limitations of this study are presented.



CIRCULAR VALUE CHAIN

The studied potential future circular value chain is presented below.
There are different feedstocks, transportations and locations than in the linear value chain.
Also, it is assumed that no dyeing is needed when using similarly colored textile wastes as raw material.



ASSUMPTIONS AND LIMITATIONS

- No dying processes needed in the circular case (recycled materials are sorted based on colour)
- Manufacturing of external parts (buttons etc.) are not included in the study
- Carbon stored in fibers = excluded
- All material loss (15,2 %) is removed as waste during the clothing manufacture phase
  - Further treatment of reject materials is not considered, unless it was a part of the correspondent emission factor
- Only one-way transportations included
- Fuel production emissions are not included in transportations
- Polyester fiber transportation not included yet (linear case)
- Most of the data represent only average values; local variation in production methods etc. is not known

CALCULATIONS

LINEAR CASE

Production of fibers:	Amount	Unit	*>>> Emissions per sweatshirt*	
Cotton	0,251769	kg	0,359526	kg (CO2e)
Polyester	0,107901	kg	0,449947	kg (CO2e)
>>> FIBERS, TOTAL	*0,35967*	*kg*	*0,809473*	*kg (CO2e)*

Sweatshirt manufacturing:	Amount	Unit	*>>> Emissions per sweatshirt*	
Yarn spinning	0,35967	kg	1,554133	kg (CO2e)
Fabric production + dyeing & finishing	0,35967	kg	2,141114	kg (CO2e)
Clothing manufacture	0,35967	kg	0,132358	kg (CO2e)
>>> MANUFACTURING, TOTAL			*3,827606*	*kg (CO2e)*

Transportations:	Distance	Unit	>> tkm	*>>> Emissions per sweatshirt*	
Ship transportation: cotton fibers to yarn spinning	6026	km	1,517159	0,04248	kg (CO2e)
Truck transportation: yarn to fabric production	280	km	0,100708	0,003928	kg (CO2e)
Ship transportation: fabric to clothing manufacture	4662	km	1,676781	0,04695	kg (CO2e)
Ship transportation: sweatshirt to wholesales in Europe	14777	km	4,506985	0,126196	kg (CO2e)
>>> TRANSPORTATIONS, TOTAL	*25745*	*km*	*7,801632*	*0,219553*	*kg (CO2e)*

>>> Linear case, total emissions	**4,856632**	**kg (CO2e)**

CIRCULAR

Production of fibers:	Amount	Unit	*>>> Emissions per sweatshirt*	
Cotton	0,251769	kg	0,083084	kg (CO2e)
Lyocell	0,107901	kg	0,366863	kg (CO2e)
>>> FIBERS, TOTAL	*0,35967*	*kg*	*0,449947*	*kg (CO2e)*

Sweatshirt manufacturing:			*>>> Emissions per sweatshirt*	
Yarn spinning	0,35967	kg	1,554133	kg (CO2e)
Fabric production	0,35967	kg	1,214245	kg (CO2e)
Clothing manufacture	0,35967	kg	0,132358	kg (CO2e)
>>> MANUFACTURING, TOTAL			*2,900737*	*kg (CO2e)*

Transportations:	Distance	Unit	>> tkm	*>>> Emissions per sweatshirt*	
Truck transportation: lyocell fibers to yarn spinning	2304	km	0,248604	0,009696	kg (CO2e)
Truck transportation: recycled cotton to yarn spinning	4152	km	1,045344	0,040768	kg (CO2e)
Truck transportation: yarn to fabric production	1972	km	0,709269	0,027661	kg (CO2e)
Truck transportation: fabric to clothing manufacture	2385	km	0,857813	0,033455	kg (CO2e)
Truck transportation: sweatshirt to wholesales in Europe	2041	km	4,506985	0,175772	kg (CO2e)
>>> TRANSPORTATIONS, TOTAL	*12854*	*km*	*7,368014*	*0,287353*	*kg (CO2e)*

>>> Circular case, total emissions	**3,638037**	**kg (CO2e)**

Sample of emission calculations made in Excel. The used emission factors are found from another sheet.

DATA AND EMISSION FACTORS

Production of raw materials and chemicals			
Cotton fibers	1,428	kg (CO2e) / kg	Cotton Incorporated 2016
Polyester fibers	4-5	kg (CO2e) / kg	Ecoinvent 3.8
Lyocell fibers	3,4	kg (CO2e) / kg	Schultz & Shuresh 2017
Mechanical recycling of cotton + incineration of non-spinnable fraction	0,33	kg (CO2e) / kg	European Commission 2021
Transportations			
Diesel truck, 40 t, 70 % load, highway driving	0,039	kg (CO2e) / tkm	VTT Lipasto
Container ship, 2000 TEU, 65 % load	0,028	kg (CO2e) / tkm	
Textile manufacturing processes			
Knit yarn production	4,321	kg (CO2e) / kg	Cotton Incorporated 2016
Garment production processes - knit collar shirt	3,376	kg (CO2e) / kg	
Batch dyeing - knit collar shirt	2,577	kg (CO2e) / kg	
Cut-and-sew - knit collar shirt	0,368	kg (CO2e) / kg	

- The secondary data needed in calculations is listed here.
- As the information sources vary, there may be some inconsistency in the study methods behind these emission factors.
- Most of the data is from public sources, representing the average emissions from given process.

SOURCES OF THE EMISSION FACTORS AND OTHER DATA:

Cotton Incorporated, 2016. LCA update of cotton fiber and fabric life cycle inventory. Available from: https://resource.cottoninc.com/LCA/2016-LCA-Full-Report-Update.pdf

European Commission, 2021. Study on the technical, regulatory, economic and environmental effectiveness of textile fibres recycling. Available from: https://op.europa.eu/en/publication-detail/-/publication/739a1cca-6145-11ec-9c6c-01aa75ed71a1

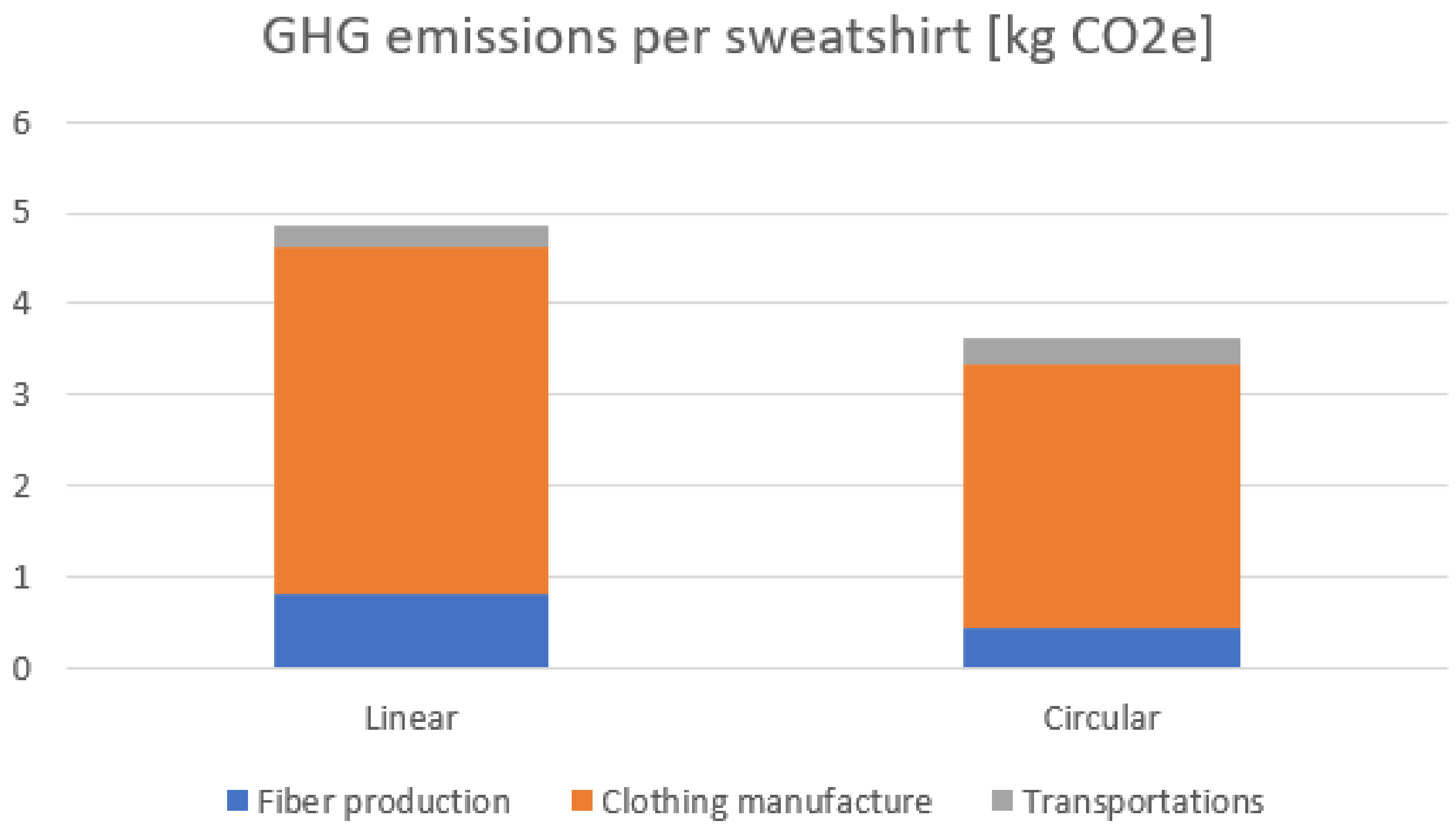
Ecoinvent 3.8 database

Schultz & Shuresh, 2017. Life Cycle Assessment Comparing Ten Sources of Manmade Cellulose Fiber. Available from: https://cdn.scsglobalservices.com/files/resources/SCS-Stella-LCA-MainReport-101017.pdf

VTT, 2017. LIPASTO - traffic emissions database. Available from: http://lipasto.vtt.fi/yksikkopaastot

Schultz & Shuresh, 2017. Life Cycle Assessment Comparing Ten Sources of Manmade Cellulose Fiber. Available from: https://cdn.scsglobalservices.com/files/resources/SCS-Stella-LCA-MainReport-101017.pdf

PRELIMINARY RESULTS



- With the given limitations, it seems that the circular case would produce 25 % less greenhouse gas emissions.
- Most savings come from the avoided dyeing process, but also different fiber inputs could have some climate benefits.
- Actual global warming potentials may be very different, if e.g. soil organic carbon and local energy production methods were accounted.

→ These results must be viewed only as preliminary examples!

CONCLUSION

- ***With the limitations and assumptions used in the study,*** GHG emissions decrease when moving from a linear product chain to a circular economy product chain as well as global warming potential of the product manufacture will decrease.
- The biggest change is in clothing manufacture phase. Fabric is not dyed in the circular version, which proved to be the most significant factor.
- Emissions from fiber production decrease by about half when comparing linear and circular cases. Biogenic carbon balance could not be assessed in this study.
- Even though the total transportation distance is smaller in the circular case, the increased share of truck transports would bring more emissions. The role of this is negligible compared to other processes.

THOUGHTS AND QUESTIONS DURING THE STUDY

- Data needed from real life to get a reliable result
- If the demand of virgin fibers decrease, less natural resources are consumed in the circular textile system
  - For example: less land use and water consumption, if cotton cultivation is avoided
  - Actual saved amounts are hard to assess yet
- In this study, the focus was on global warming potential: the assessment of many other environmental impacts would also be VERY important
- Are the assumptions realistic? E.g., no dyeing process needed in circular case…
- Local variance: which parameters will change when moving from Asia to European countries? How will they change?
  - Currently, clothing manufacture processes are ”world average” for knit collar shirt
  - Assumptions behind the emission factors: energy production methods, wastewater treatment etc.
- How do the processes change with different fiber input?
- Circular production’s effect on the textile industry and consumer habits?