Circular and Biobased Performance Materials Symposium
19 June 2019, Wageningen, The Netherlands

Session: Using post-consumer waste for new materials
Presentation by: Edwin Keijsers, *Wageningen Food & Biobased Research*

Title: **Refining of post-use materials**

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Curriculum:
Edwin Keijsers (MSc) is a chemical process engineer, employed as scientist at Wageningen University and Research in the institute Food and Bio-based Research. Since 1997 he has led projects on the use of alternative raw materials for feed, fibre and energy applications. Projects include: development of a biorefinery based on fresh grass for feed, energy and materials, pre-treatment of grasses and straw for the production of bioethanol and bio-hydrogen by fermentation, use of hemp and agricultural waste materials as alternative fibres in paper, use of biobased fibres and glues in board materials (Banana, Straw, Reed, Coir), production of bio-composites of e.g. starch, PLA and natural fibres. The projects combine the technical development of the product and (small scale) processes with the general implication of the new use of raw (waste-) materials on durability, the environment and the community. Projects were performed in close contact with and (partly) funded by industry. Several projects resulted in ready to market and available products e.g. Dutch Cotton (a hemp based alternative for cotton security paper), a cardboard tomato container made from tomato leaves, pulp moulded products made from grass fibres and coir based panels.

Abstract:
In the shift towards a biobased and circular economy the role of lignocellulosic materials will increase. Besides virgin materials (Wood, Miscanthus, hemp), sidestreams (tomato stalks, grass), post-use fibrous materials will be more and more used as raw material. Currently some post-use fibrous materials are recycled to a large extent (e.g. paper), others are composted or used as energy source. The high purity of virgin raw materials contrasts sharply with some circular materials obtained from e.g. household wastes and sewage. Other circular sources, e.g. recycled paper are relatively pure. Already the fibre and cellulose based industries use both biobased and circular raw materials. However, traditionally, due to e.g. (food-)safety reasons there are only few industries that mix virgin and recycled materials. Chemical and mechanical processes developed to produce fibres and cellulose from virgin raw materials cannot be directly used to process circular raw materials because of the contaminations present. Examples of different projects to obtain fibres and cellulose from circular raw materials are given and an overview of the possible refining processes is shown.

Refining of post-use materials

Circular and Biobased Performance Materials Symposium

19-6-19, Edwin Keijsers

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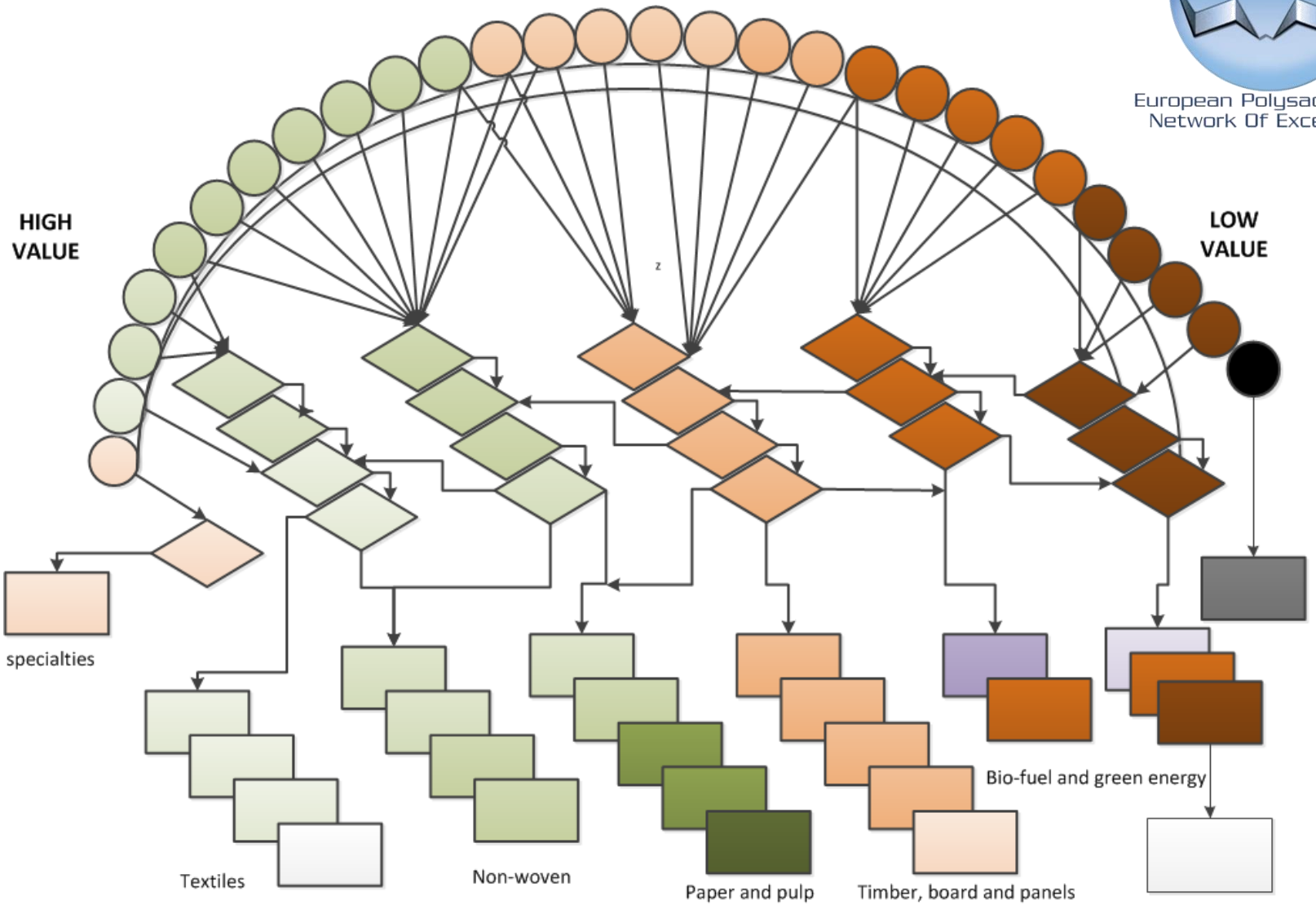
100years
1918 — 2018

Introduction

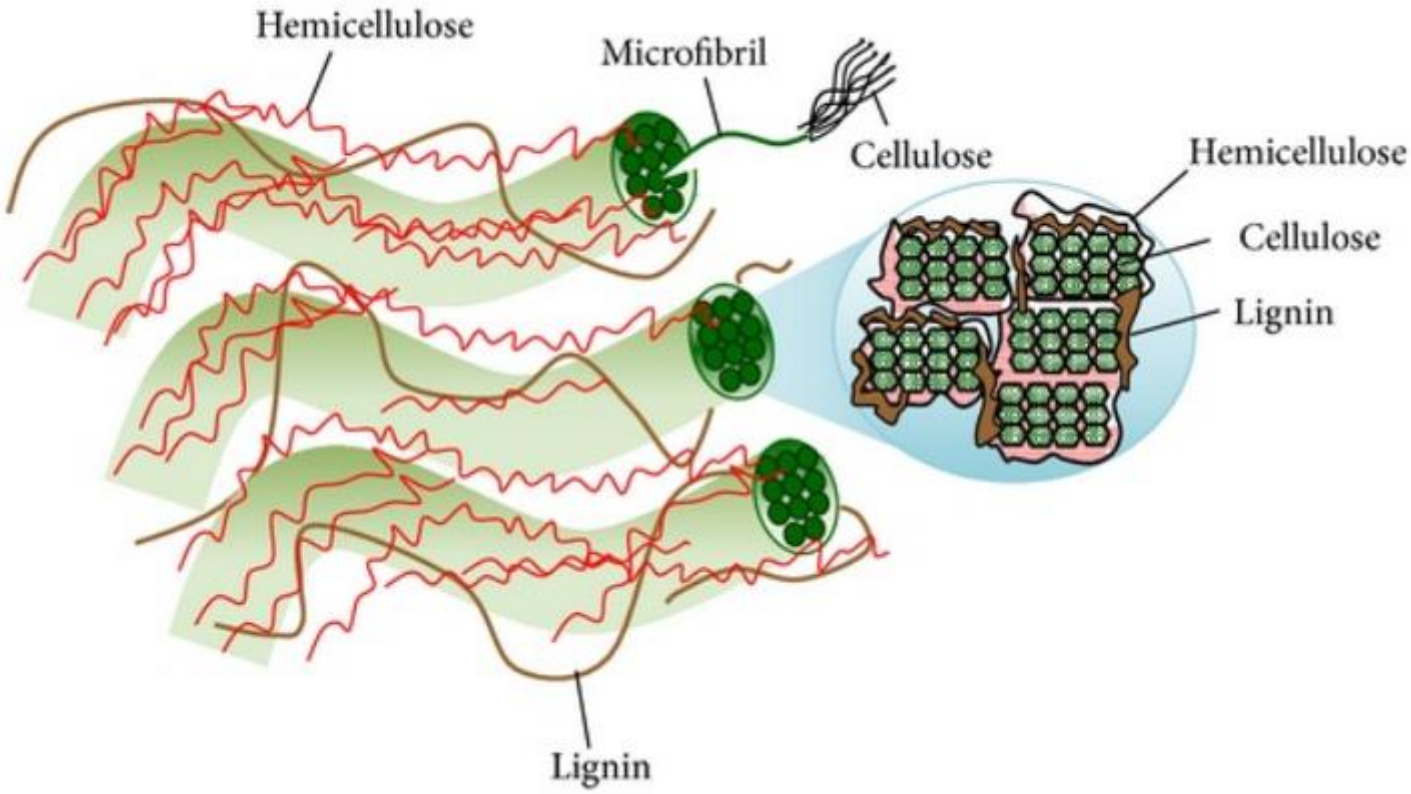
- Cellulose resource matrix
  - Fibre properties
- Recycling of fibres
  - Refining options
- Examples
  - Textile
  - Coffee cups and Beverage Cartons
  - Construction and Building materials

Cellulose resource matrix

epnoe
European Polysaccharide Network Of Excellence



Chemical structure



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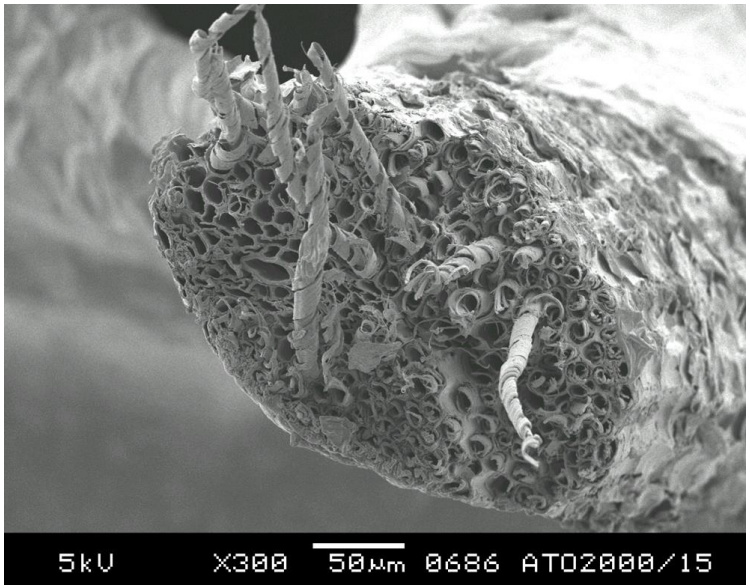
1918 — 2018

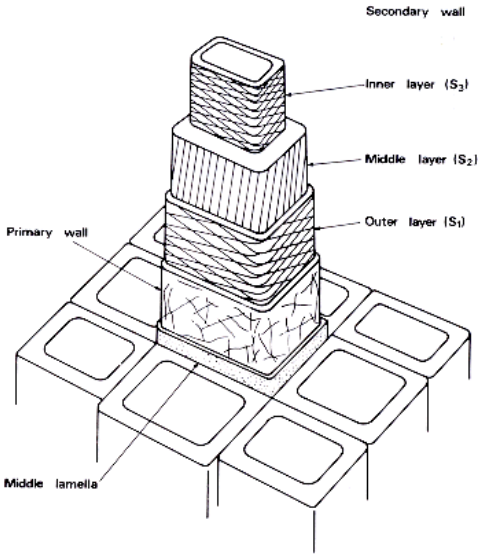
Review Article
Conversion of Lignocellulosic Biomass to Nanocellulose: Structure and Chemical Process

Chemical and physical properties

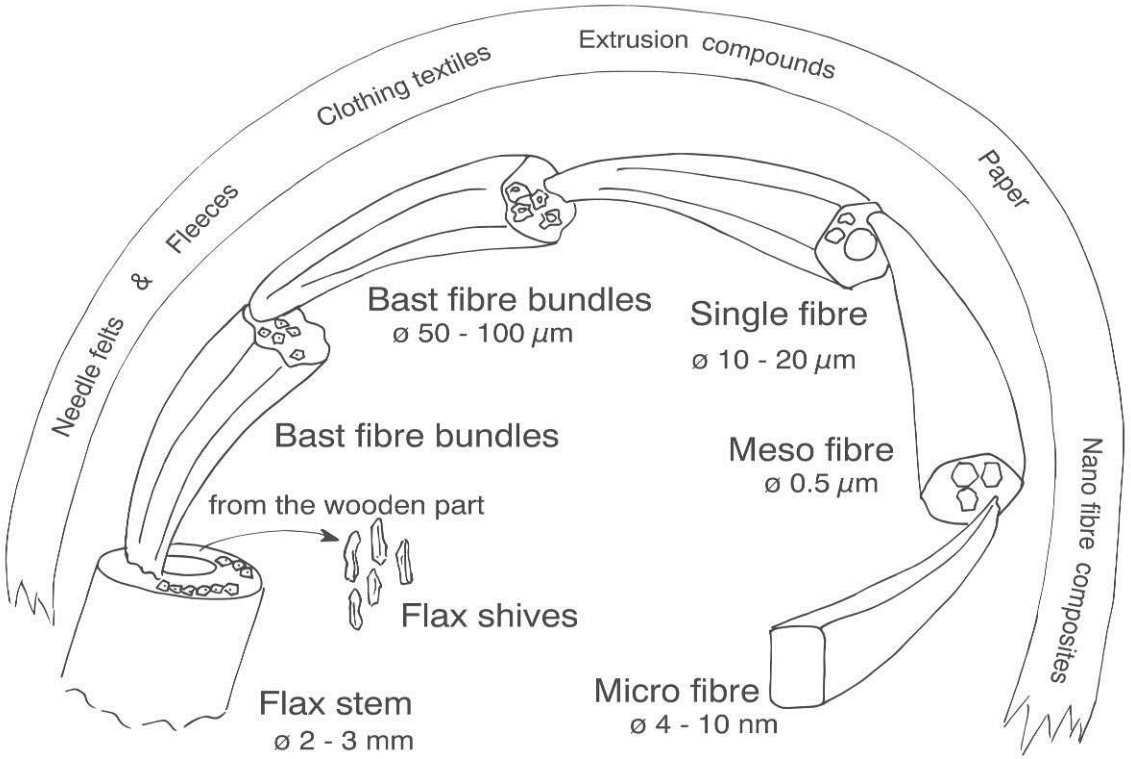
- Fibre dimensions
  - Fibre length
  - Diameter
  - Lumen
  - Cell wall thickness
- Cellulose properties
  - cellulose fibre strength properties
  - microfibril orientation
  - density
  - polymerisation degree / Molecular mass distribution
  - swelling
  - solubility in alkali / ionic liquids
- Cellulose quality parameters
  - purity
  - DP
  - crystallinity / amorphous phase



Cellulose resources

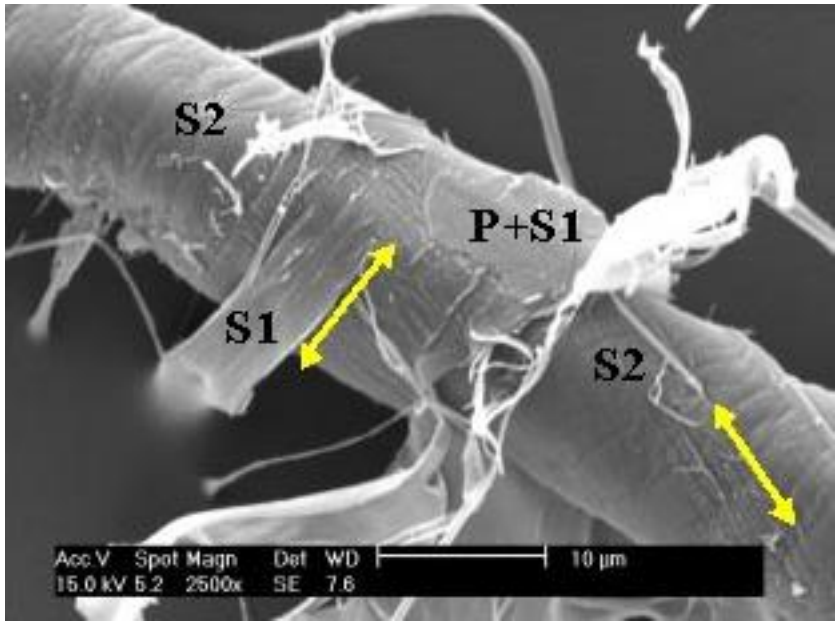


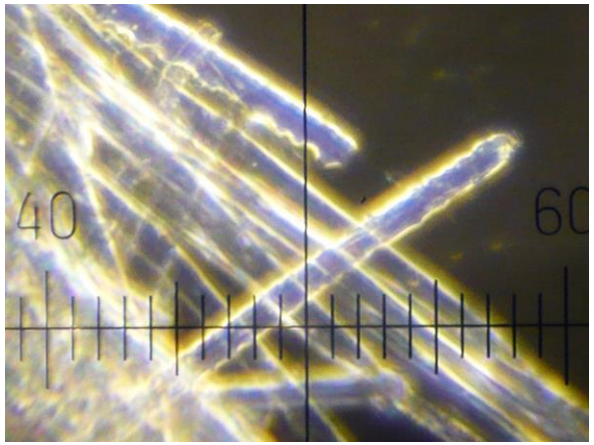
Wood



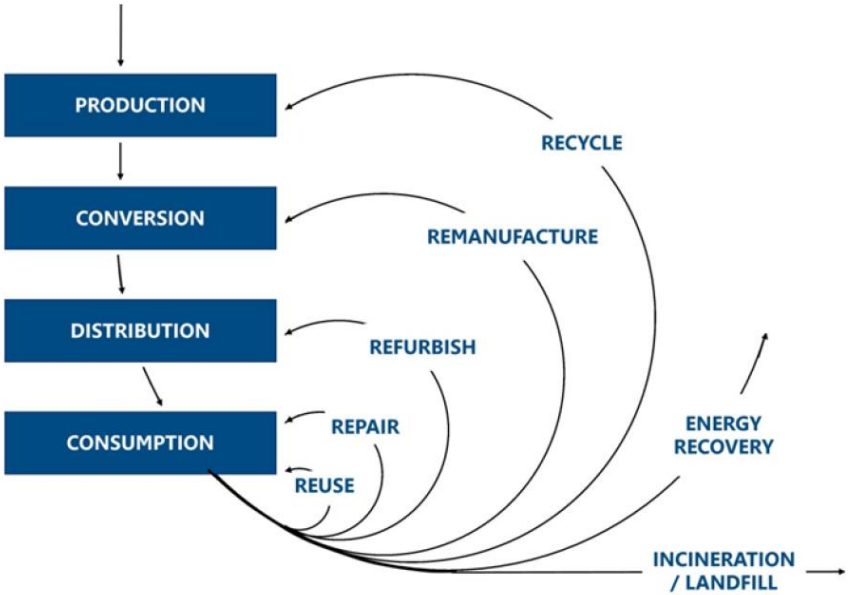
Flax

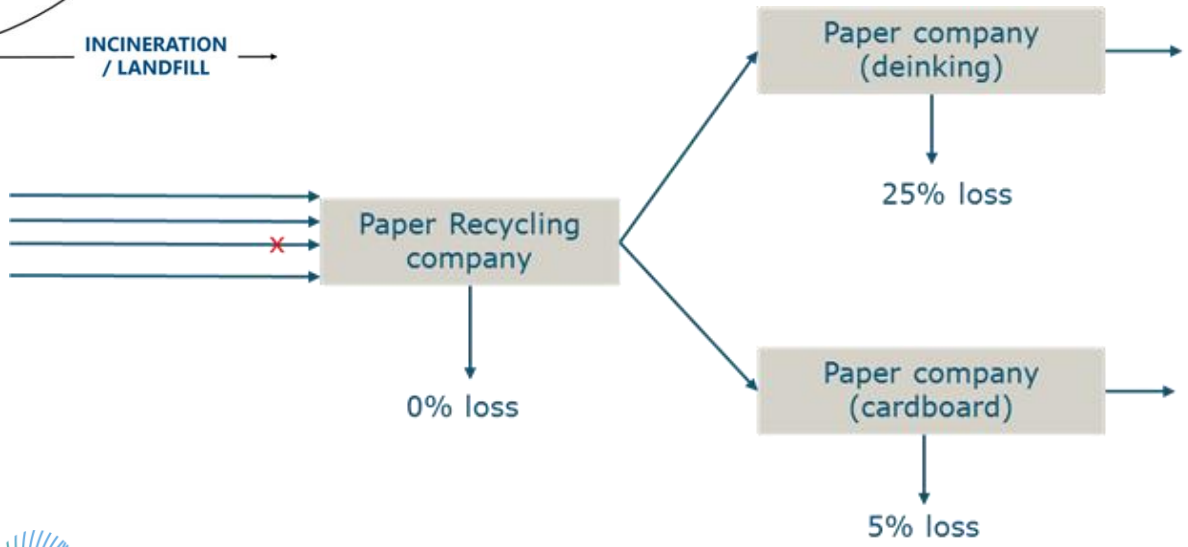
Cellulose resources



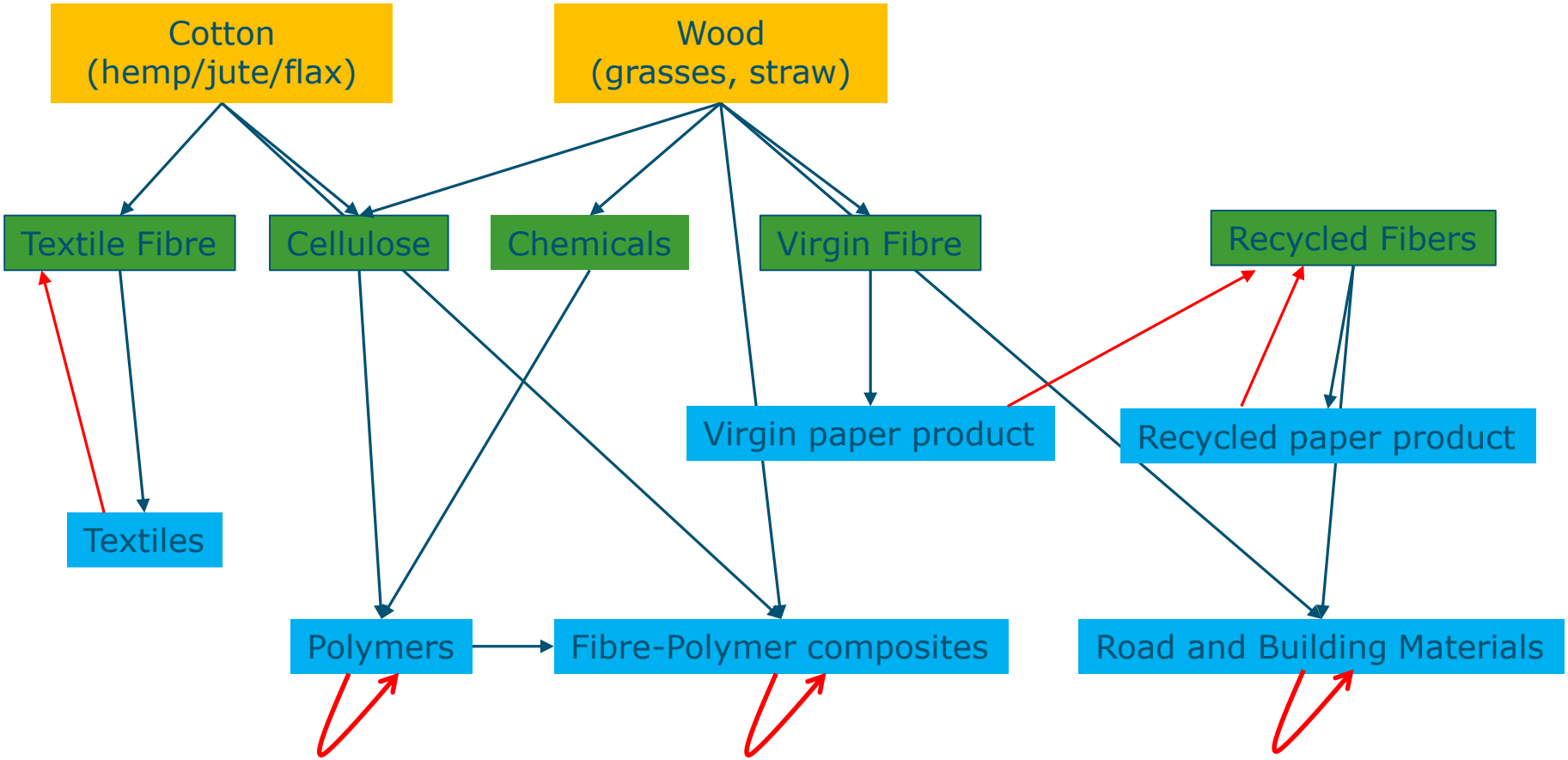


Recycling


PRODUCTION
CONVERSION
DISTRIBUTION
CONSUMPTION
RECYCLE
REMANUFACTURE
REFURBISH
REPAIR
REUSE
ENERGY RECOVERY
INCINERATION / LANDFILL

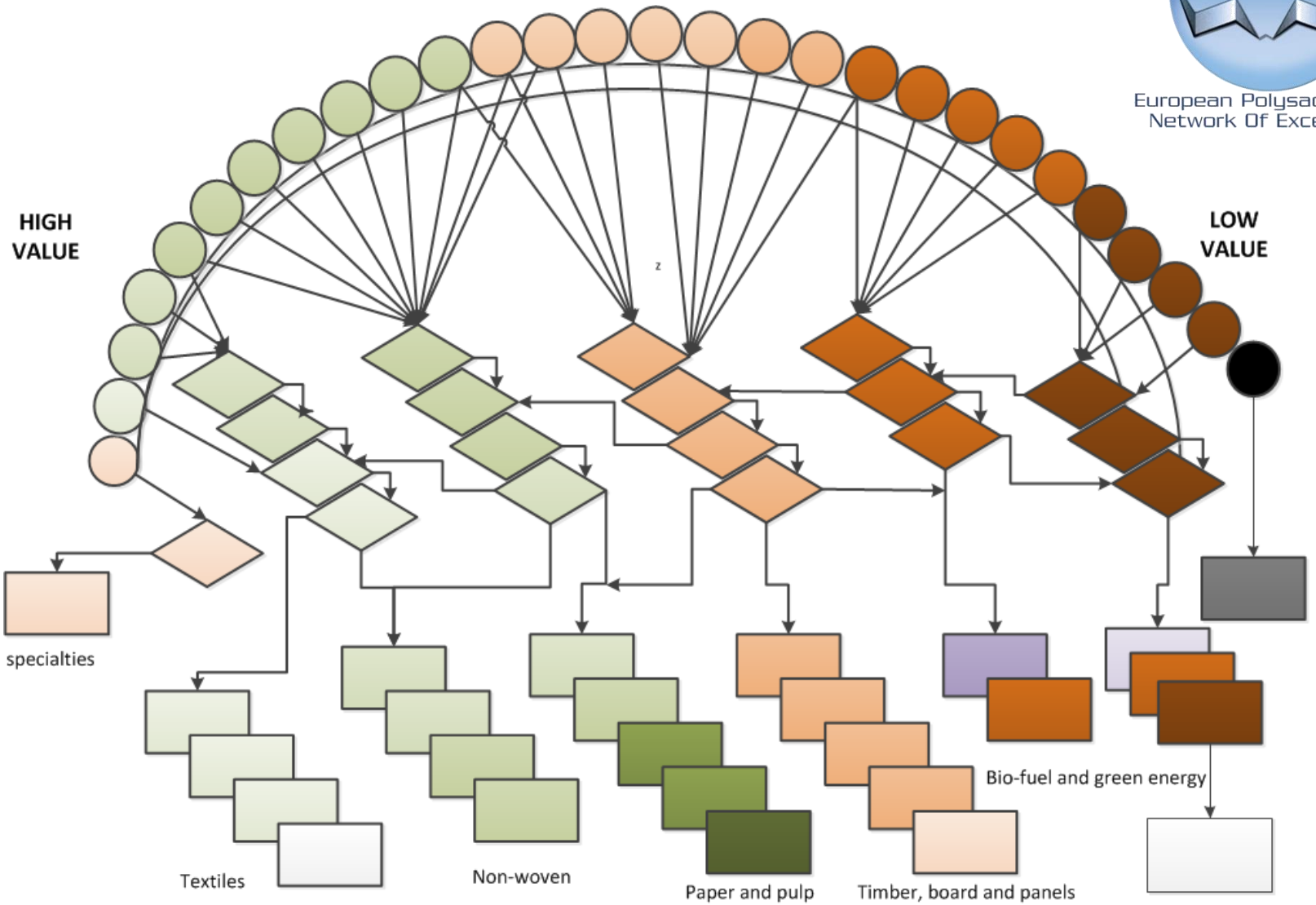

Paper Recycling company
0% loss
Paper company (deinking)
25% loss
Paper company (cardboard)
5% loss

Fibre recycling



Cellulose resource matrix

epnoe
European Polysaccharide Network Of Excellence



Upgrading / fractionation processes

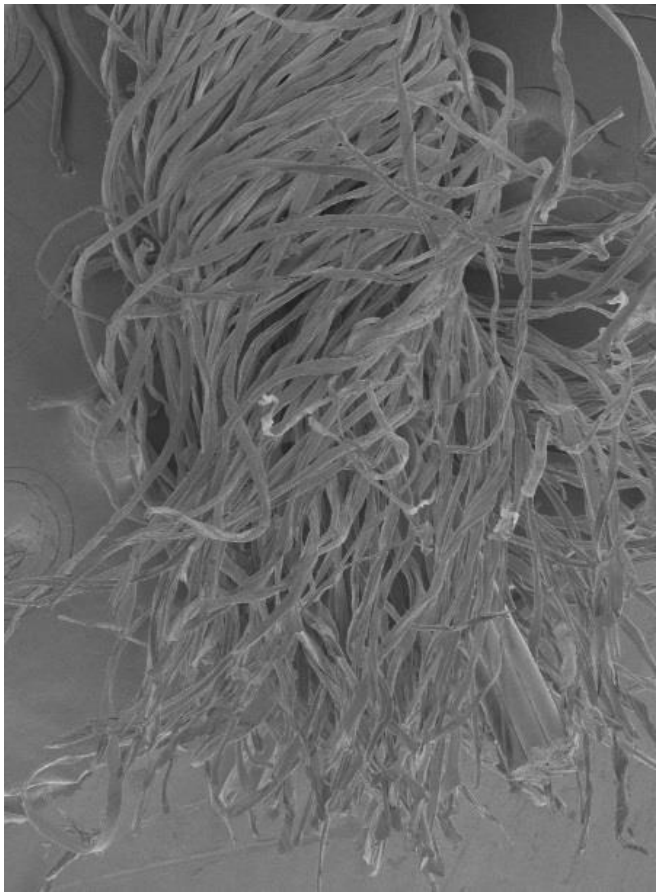
- harvesting / storage and transport
- textile processing
- cleaning / screening

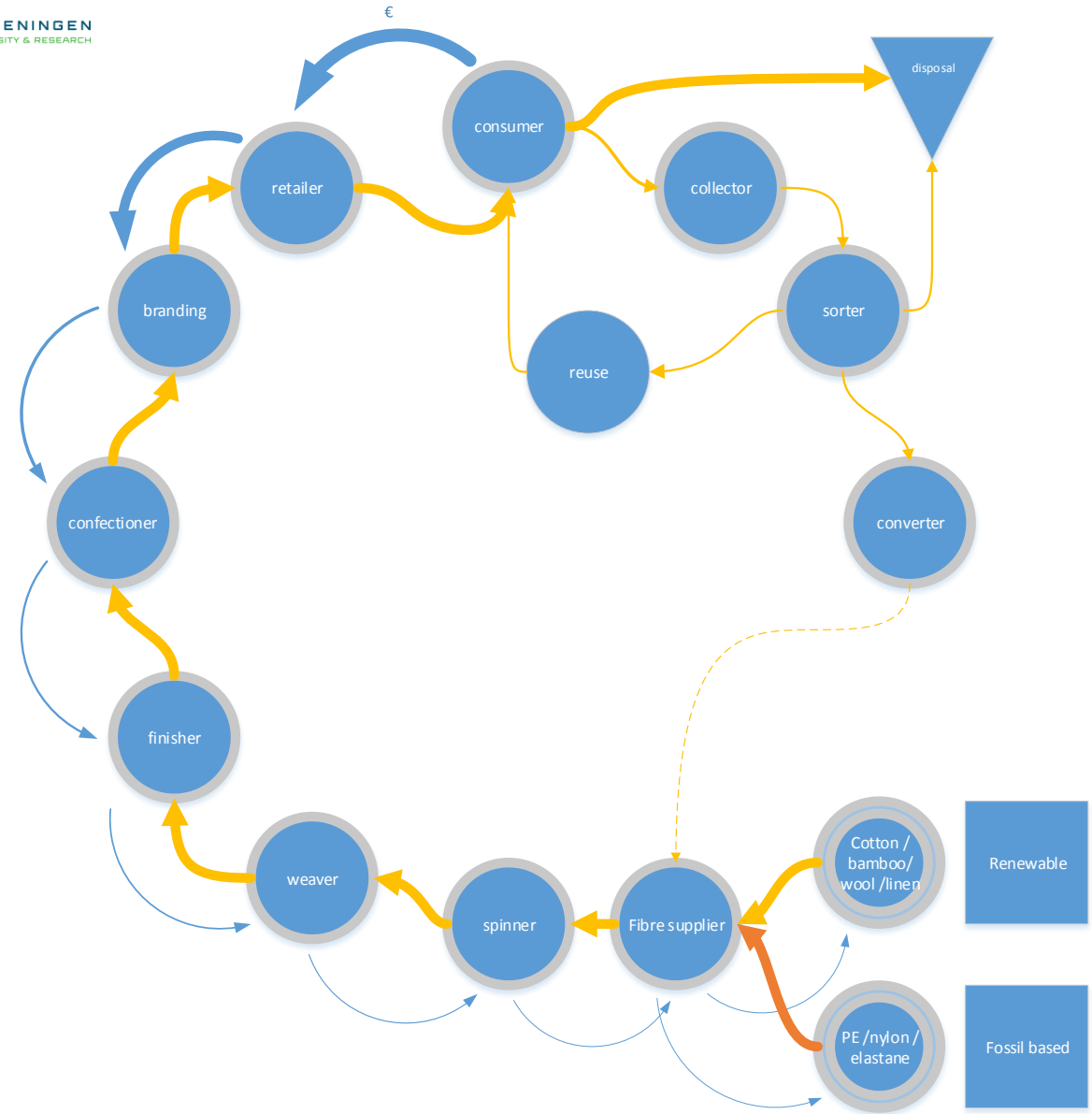
- mechanical pulp
- thermo-mechanical pulp
- Chemi-thermomechanical pulp
- kraft pulping
- sulphite pulping
- alkaline pulping
- organosolv pulping
- acetosolv pulping / MILOX

- steam explosion / ultrasonication
- hydrolysis (enzyme)
- pyrolysis / hydrothermal liquefaction / hydrogenation (HTU) / syngas
- activated carbon
- biopulping / white rot fungi

- viscose process
- lyocell process NNMO
- other processes ammonia / phosphoric acid
- ionic liquids
- nanocellulose

Textile recycling loop





WASTExCEL / Bio2HighTex

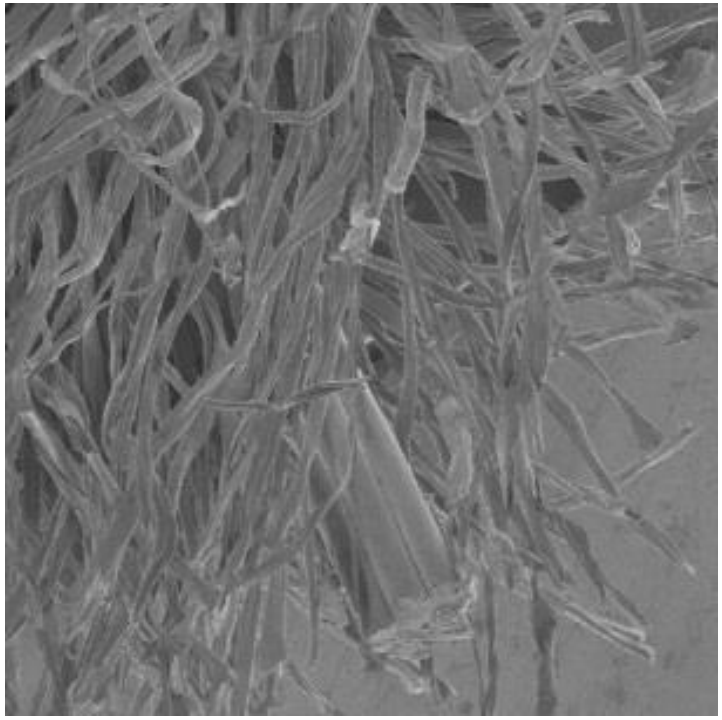
Europese Unie

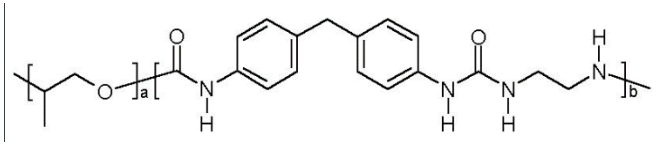
OPoost operationeel programma oost

Europees Fonds voor Regionale Ontwikkeling

- Selective extraction of cotton from mixed textile
  - Reduce EU dependency on virgin cotton fibre
  - Increase circularity textile industry

- Separate cotton from other polymer fractions



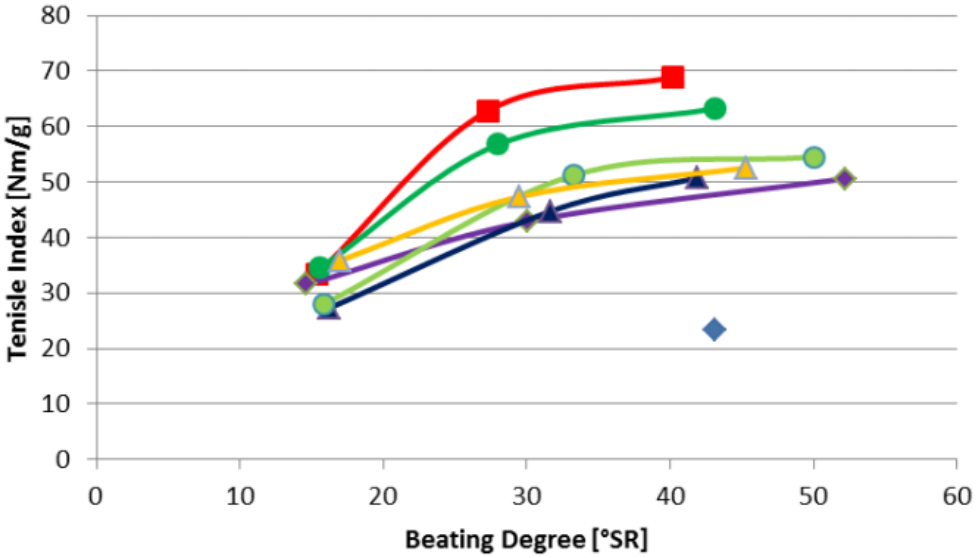


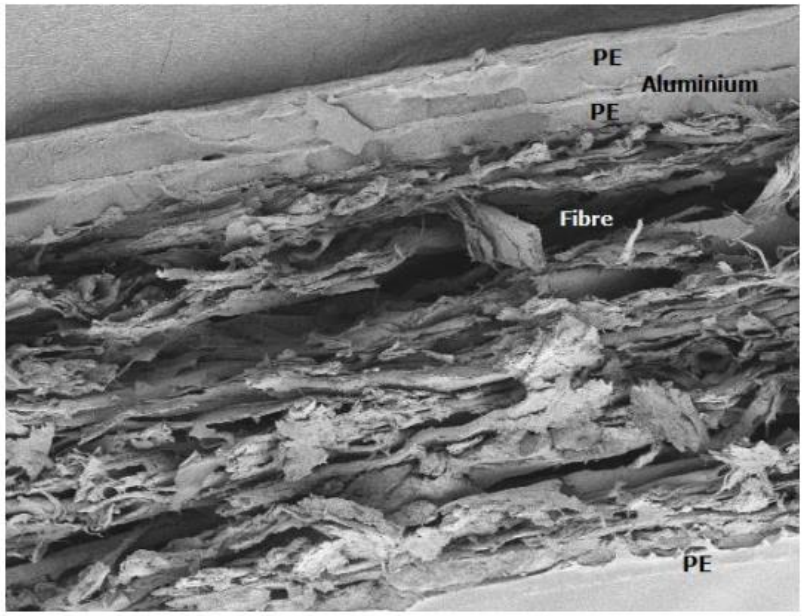
Typical structure of Elastane

Voor dit Bio2HighTex-project is een EFRO-subsidie toegekend, en subsidie vanuit Circular & Biobased Economy onder nummer KB-26-010-003

Beverage cartons and coffee cups

- Raw material: Virgin Fibres
- Use: Paper industry
  - NL: Hygiene paper
- Different collection systems
  - Prolonged pulping
  - Wet fractionation

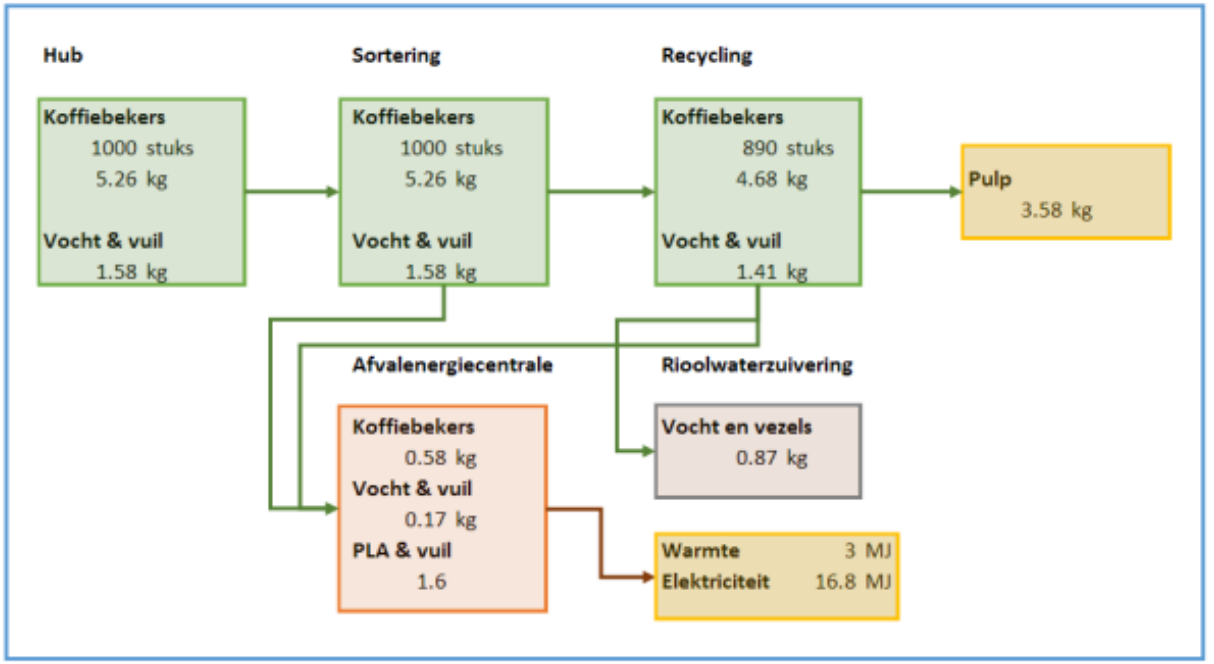




Example of beverage carton

Pilot beverage cartons, Extended technical report, 2013 dr. E.U. Thoden van Velzen, Ir. M.T. Brouwer, Ir. E. Keijsers (Wageningen UR Food and Biobased Research), prof. dr. Th. Pretz, dr. A. Feil, dipl.-ing. M. Jansen (RWTH Aachen)

Beverage cartons and coffee cups



Milieu-impact van twee verwerkingsroutes voor warme drankenbekers
Vergisting en papierrecycling van karton-PLA koffiebekers, 2018
Tom Ligthart (TNO), Martien van den Oever (WFBR)

Examples of other possible uses

Schut Papier Jeans fibres

Ecor composite panel

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Questions?