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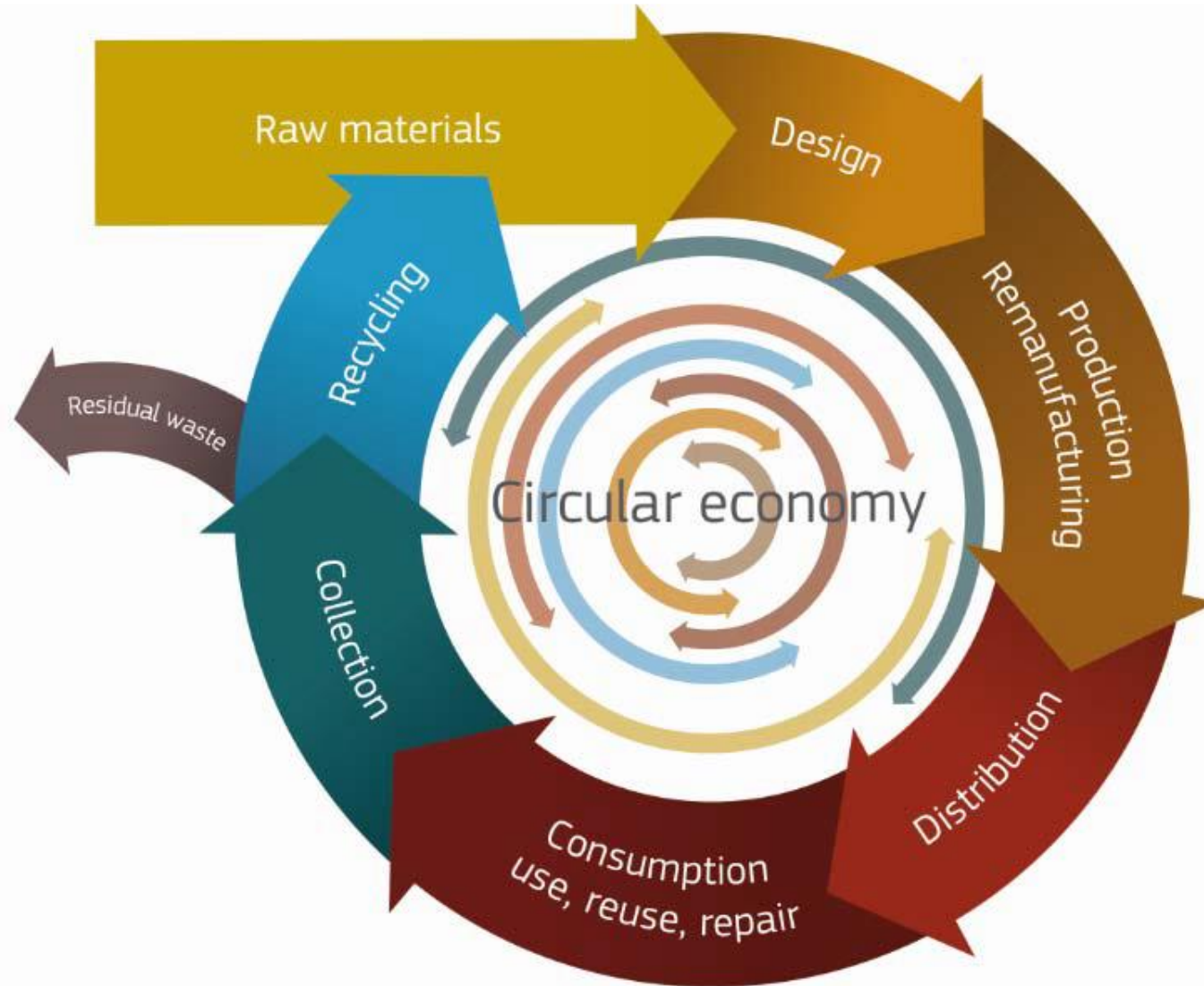


Science and Research for Circular Economy
24th October 2019

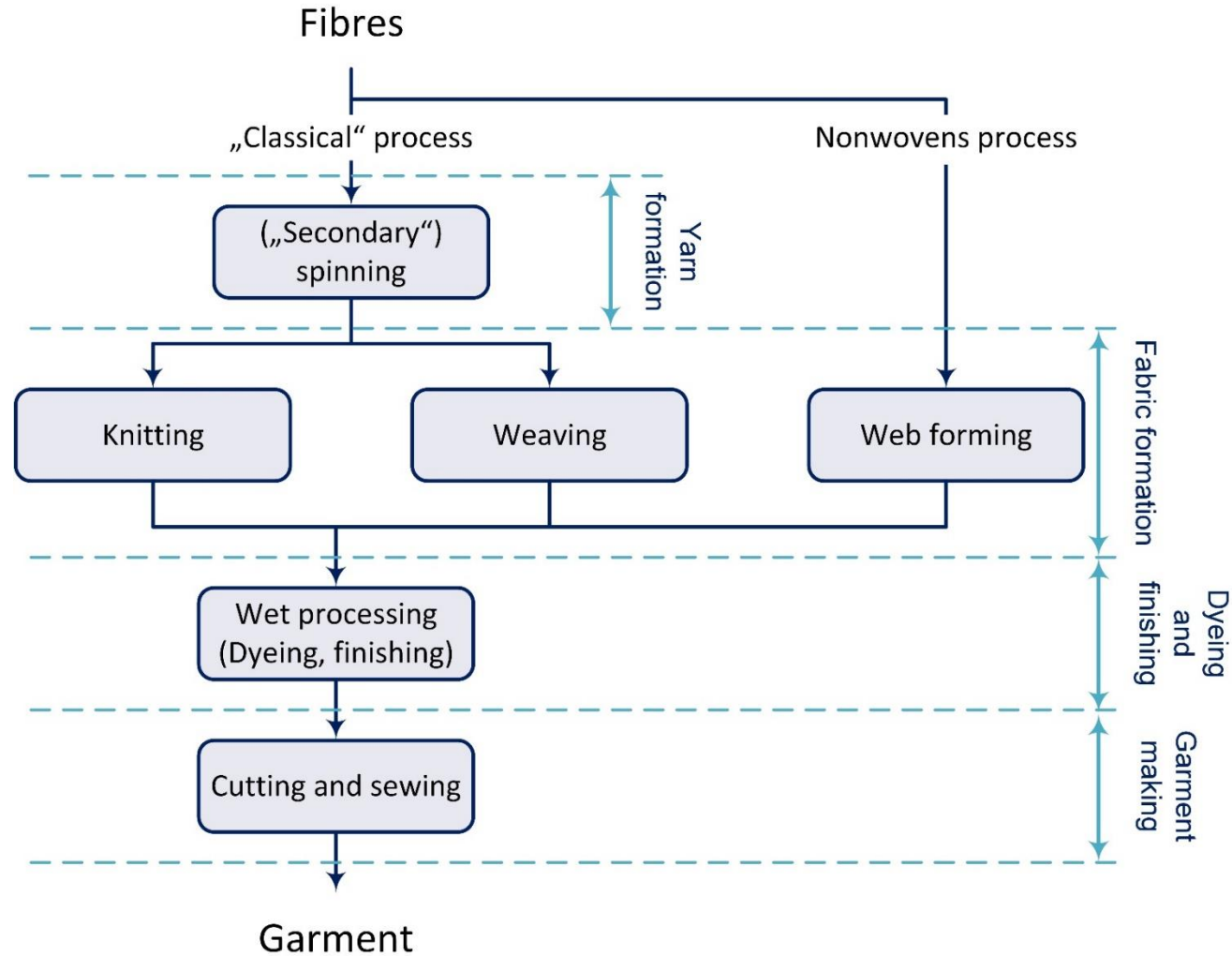
Textiles in a Circular Economy

Andreas Bartl

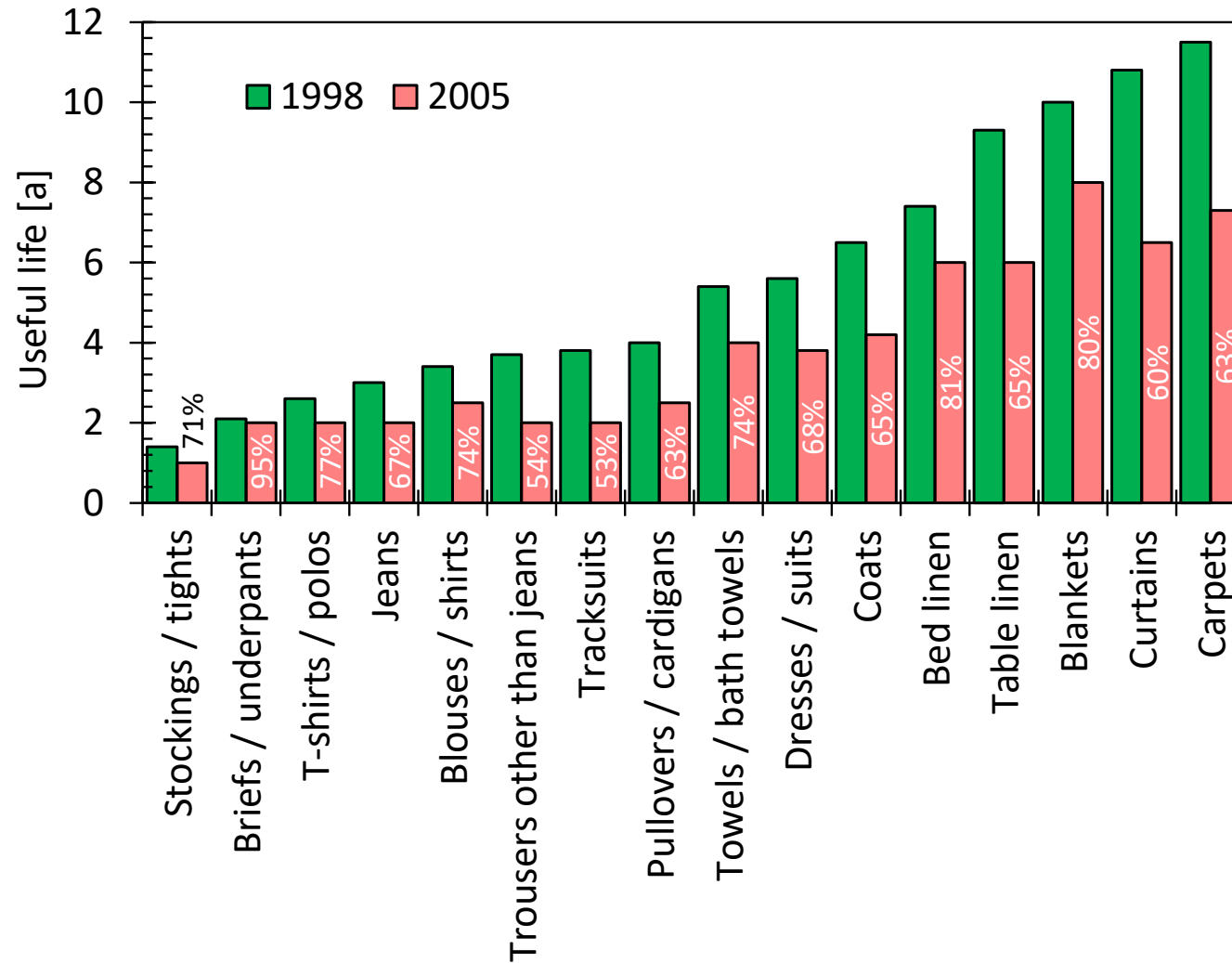
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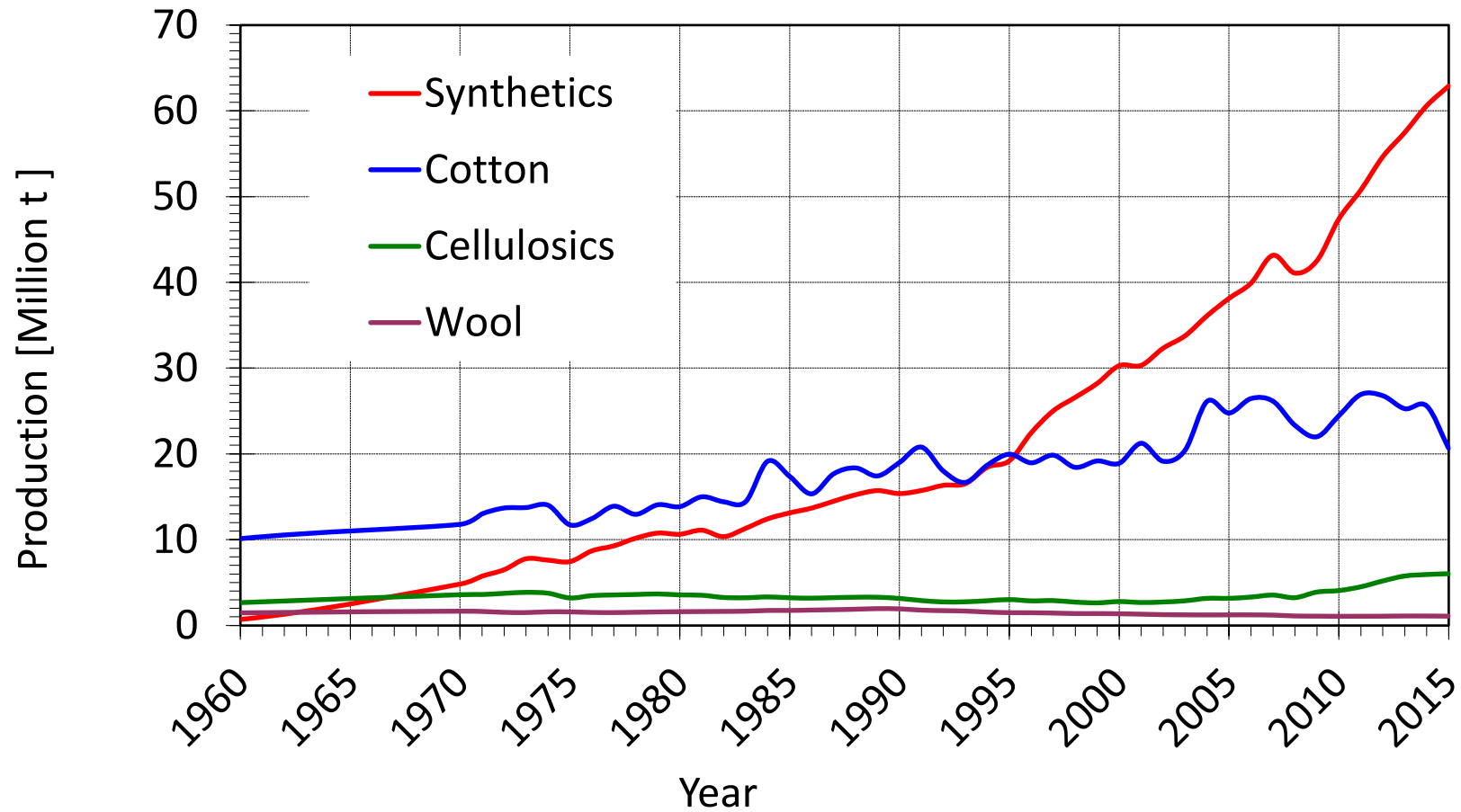
- The textile processing chain



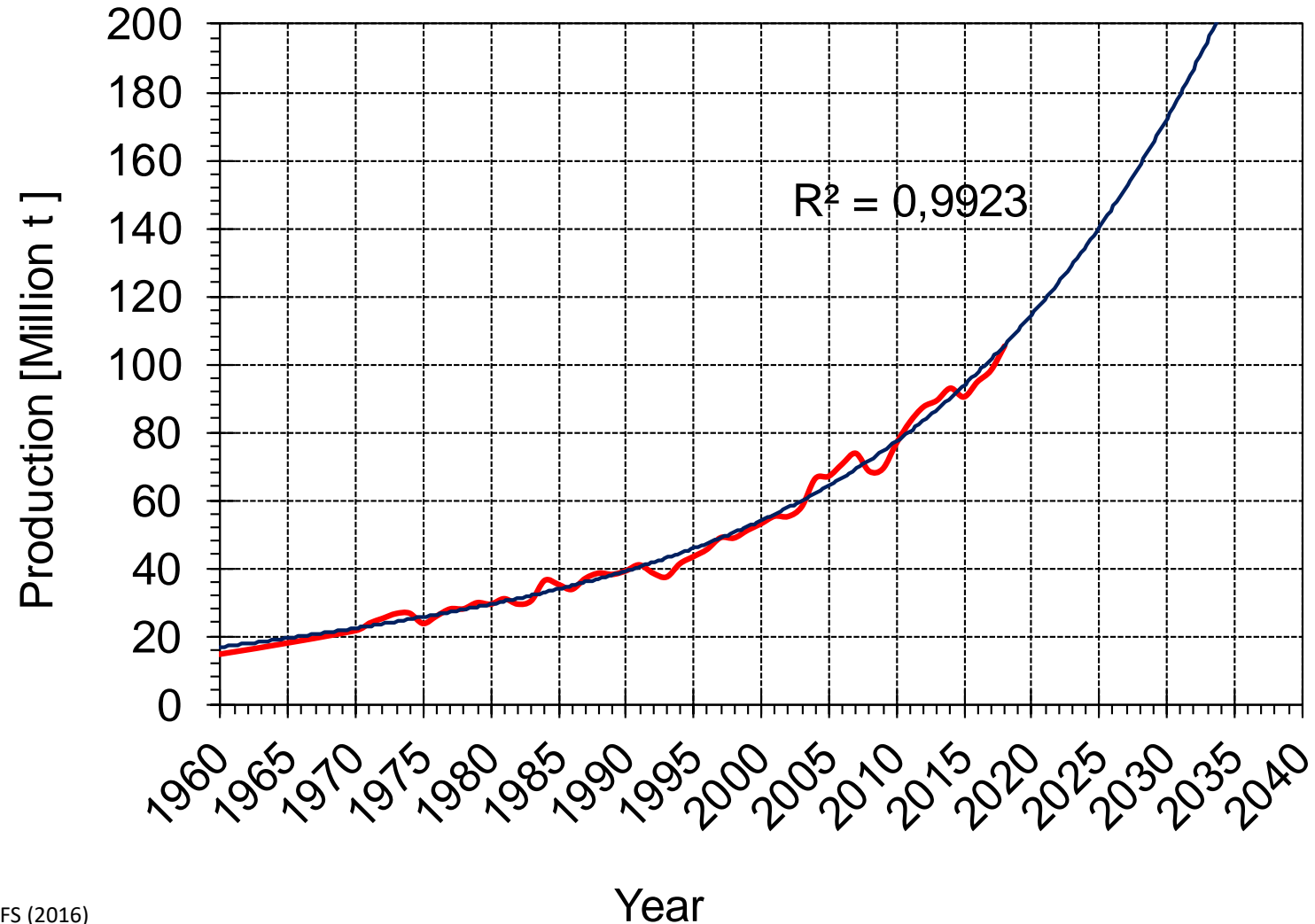
- Useful lifetime of textiles is decreasing

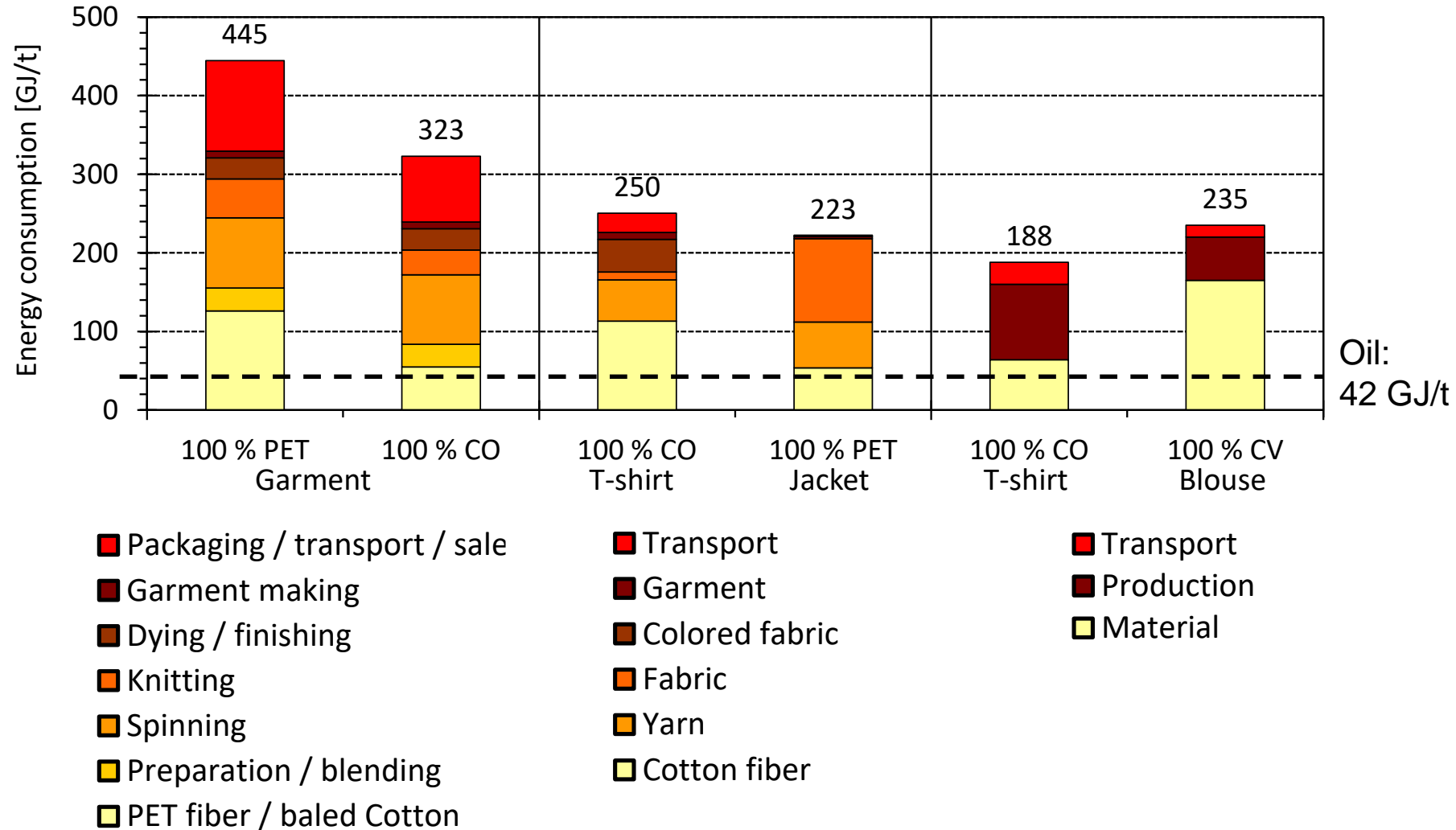


- Word fiber production by main categories



- Strong increase in the future





- Current Directive
 - Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives
- New Directive
 - Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste

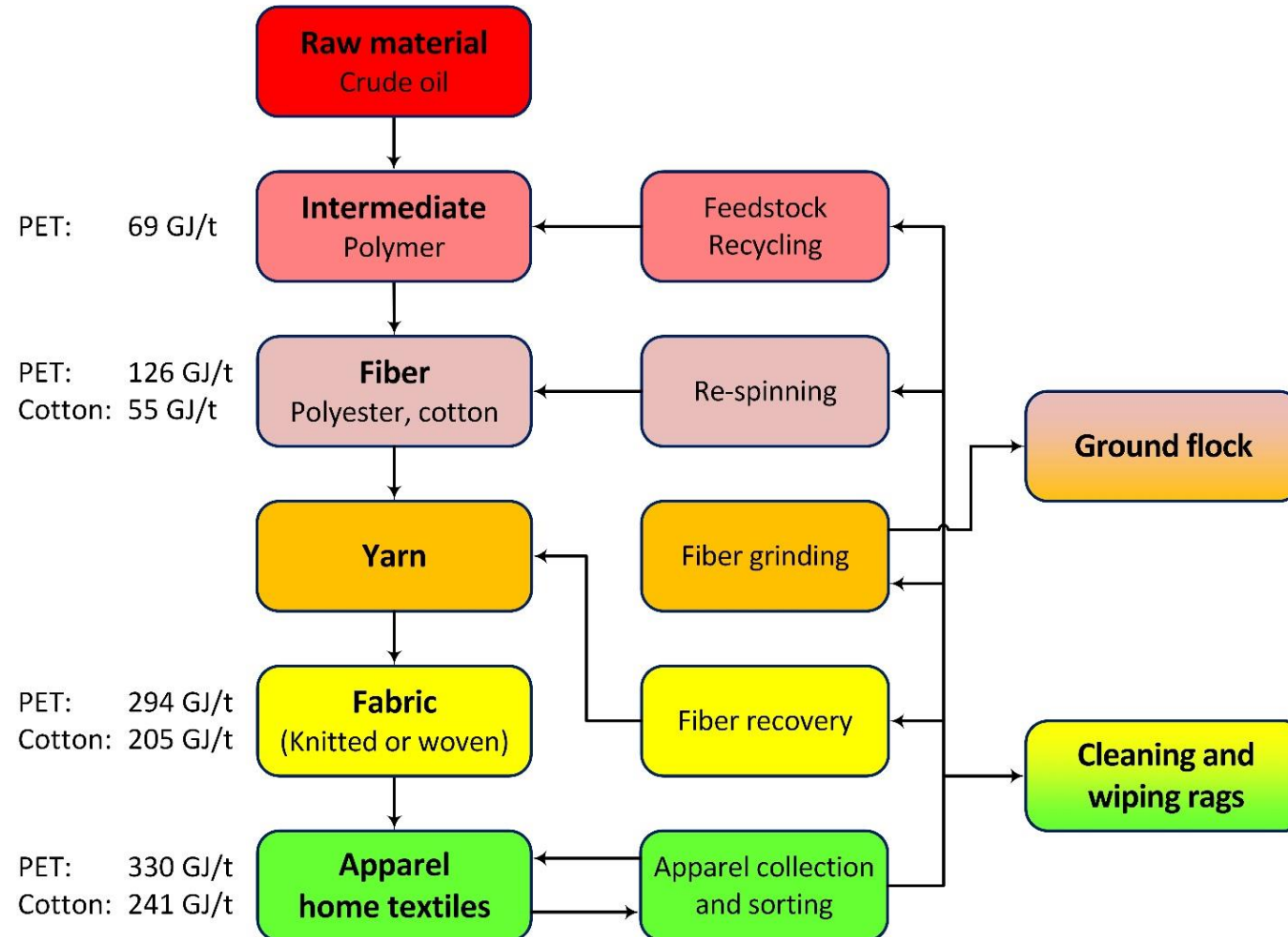
- Amendments concerning textiles
 - Article 3(2b)
Textiles count to MSW

 - Article 9(1d)
Encourage the re-use of products and the setting up of systems promoting **repair and re-use** activities for textiles

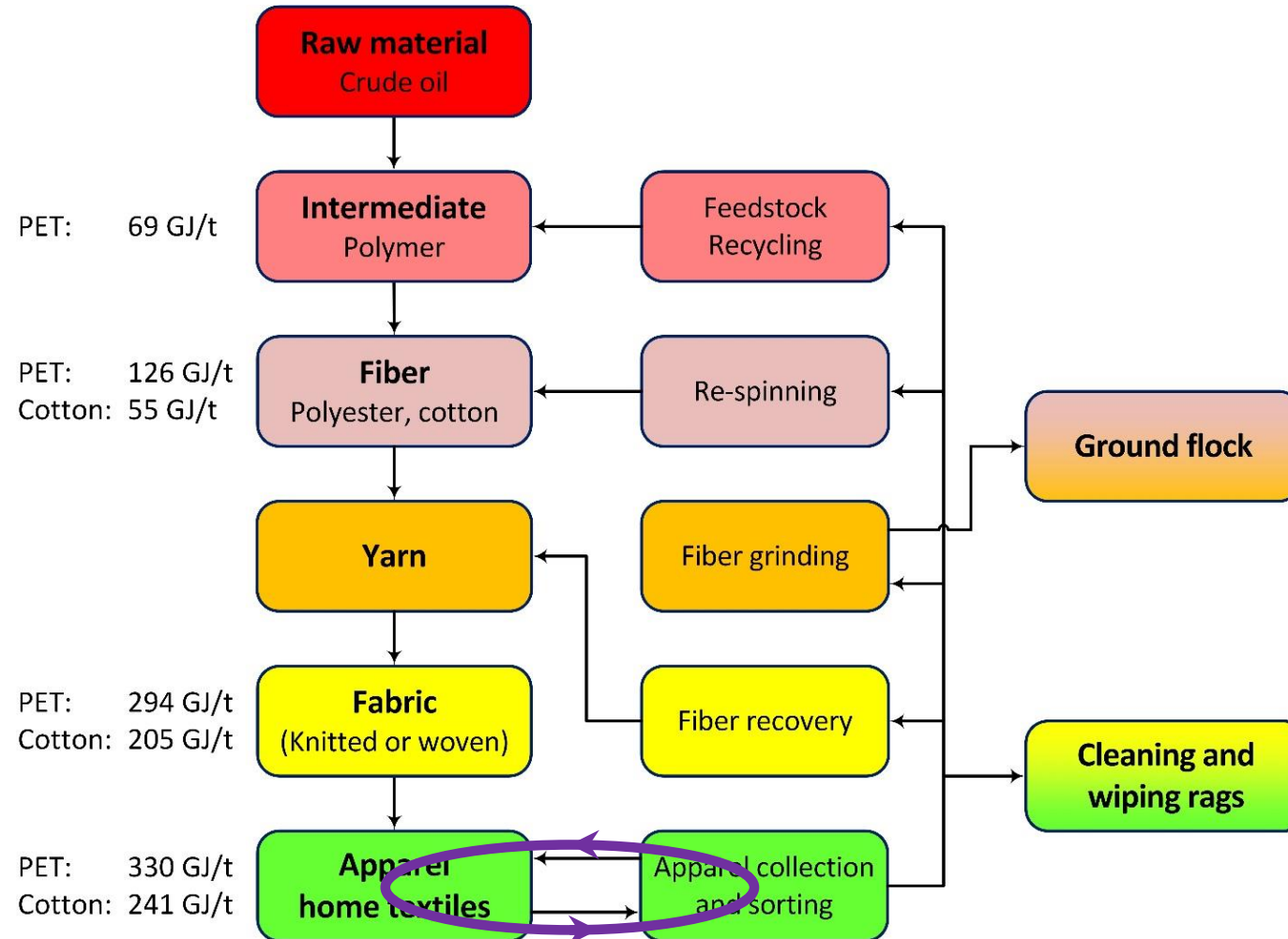
 - Article 11 (1)
Separate collection for textile waste by 1 January 2025

 - Article 11 (6)
Targets for preparing for re-use and recycling for textile waste by 31 December 2024

- Routes for re-use and recycling

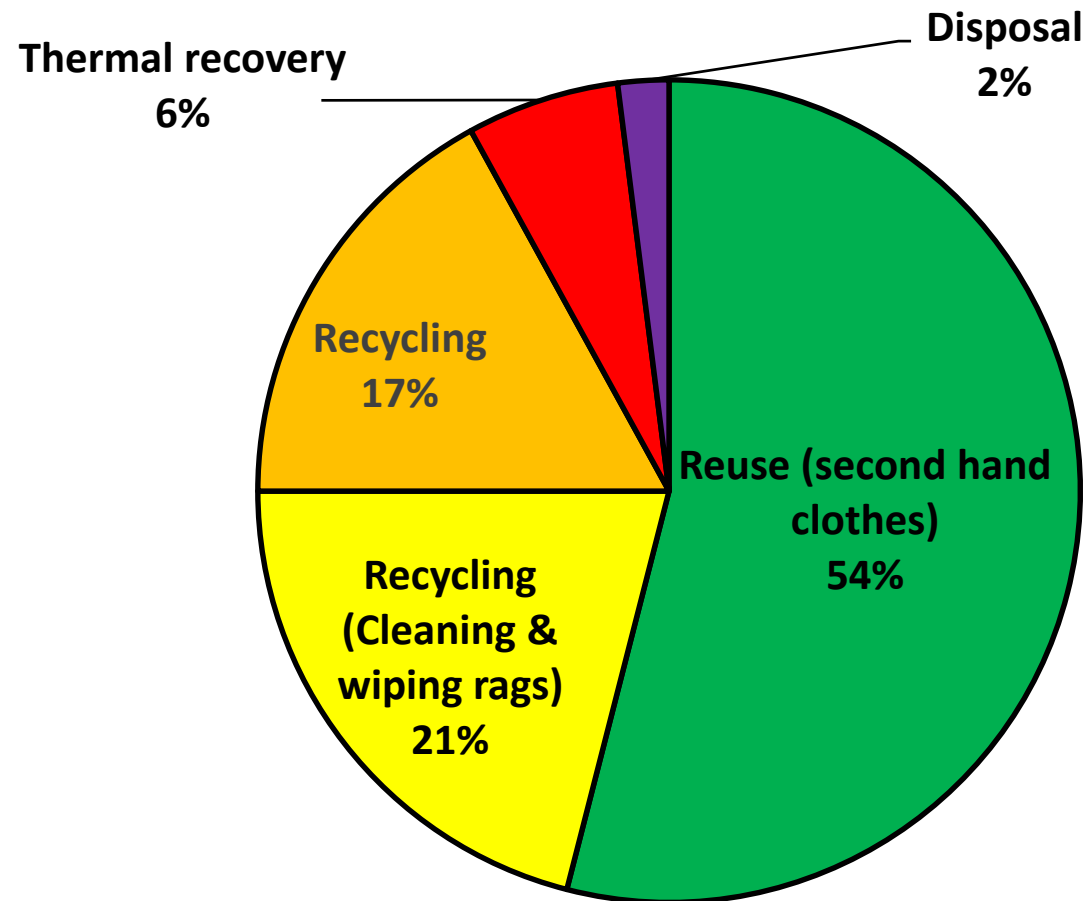


- Re-use of textiles (Second-hand clothes)



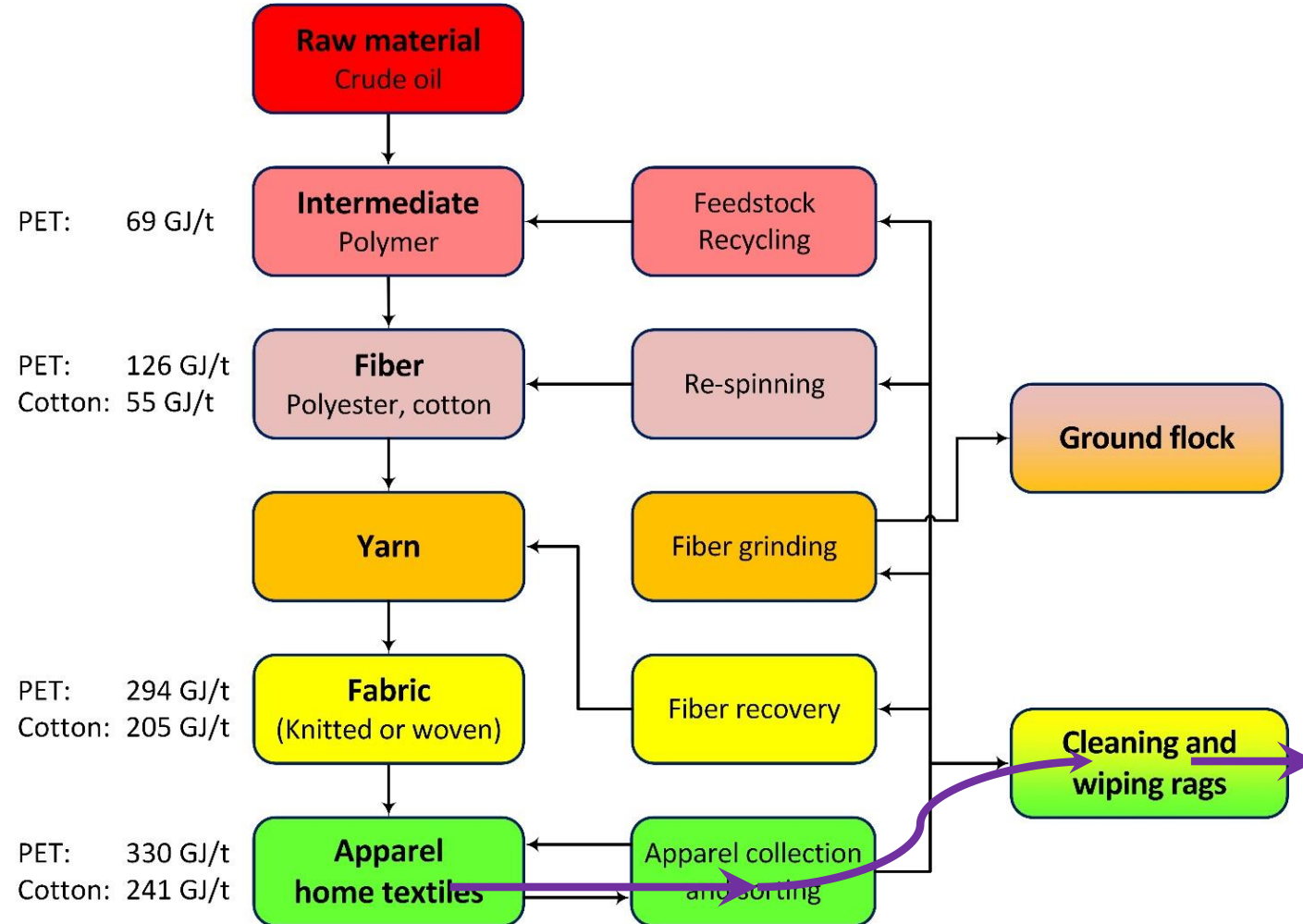
- For re-use separate collection
 - Any comingling with other waste makes re-use impossible
 - Separate collection of post-consumer textiles for re-use absolutely necessary
- Collection schemes
 - Collection campaign
 - Recycling center
 - Container collection
- Energy consumption
 - Approx. 0.35 GJ/t (collection, sorting, etc.)

- Apparel sorting in Germany (2013)



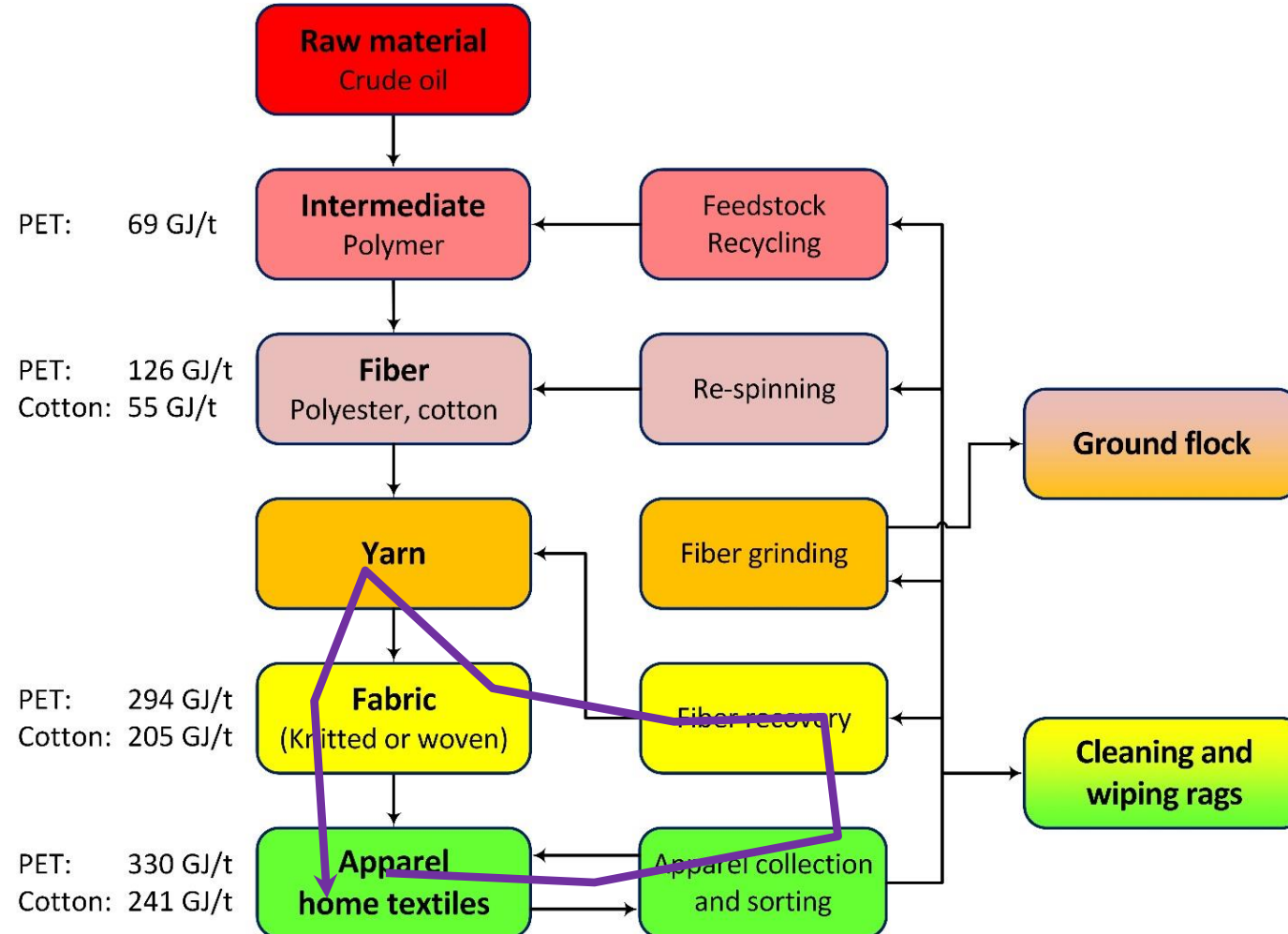
- Good or Evil?
 - Local textile industry (if there is) under pressure
 - Local textile industry suffers more from cheap imports from Asia (China)
 - Poor consumers cannot afford new clothing
 - 90 % of Ghananians purchase second hand clothes
 - Jobs (trade, distribution, repair, ...) are created
 - 24,000 jobs in Senegal
 - Import ban
 - Zimbabwe introduced ban in 2015
 - Ban has been relaxed, local textile industry not ready
 - EAC (East African Community) by 2019

- Cleaning and wiping rags



- Re-use or recycling?
- Feasible for damaged clothing
- Price level: 1,200 – 1,600 €/t
- Elaborate production
 - 20 x 30 cm
 - No zippers, etc...
 - Mainly Cotton, Linen or Viscose
 - White or colored
 - DIN standard 61650
- Single use
 - Preferable over multi-use rags

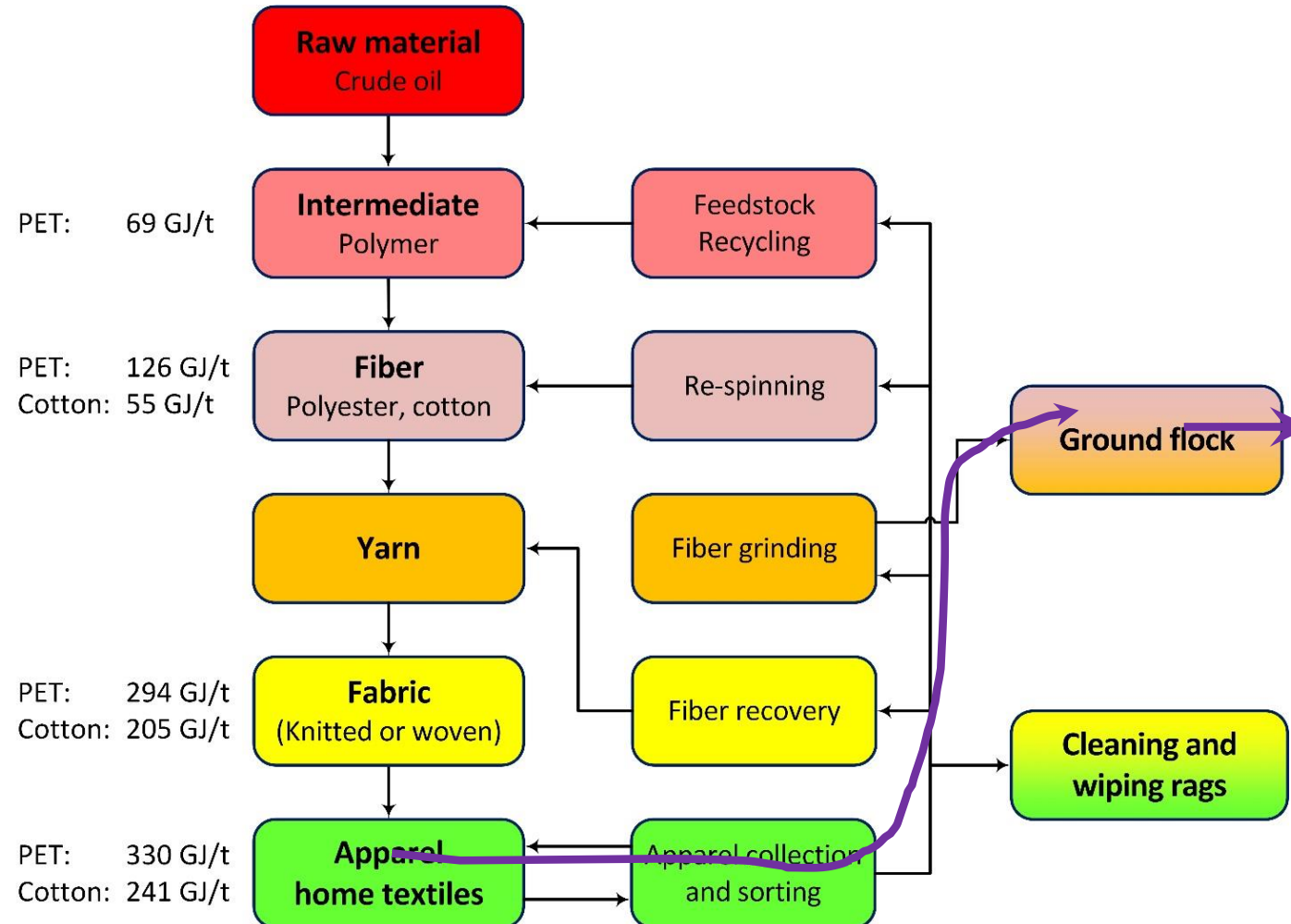
- Fiber recovery



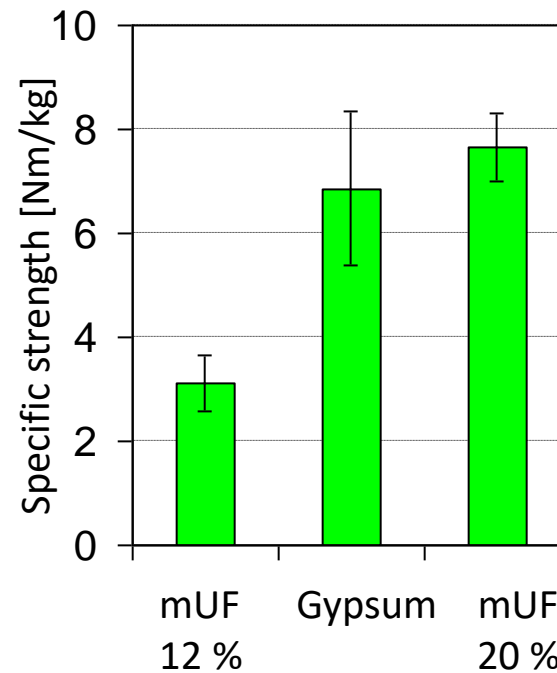
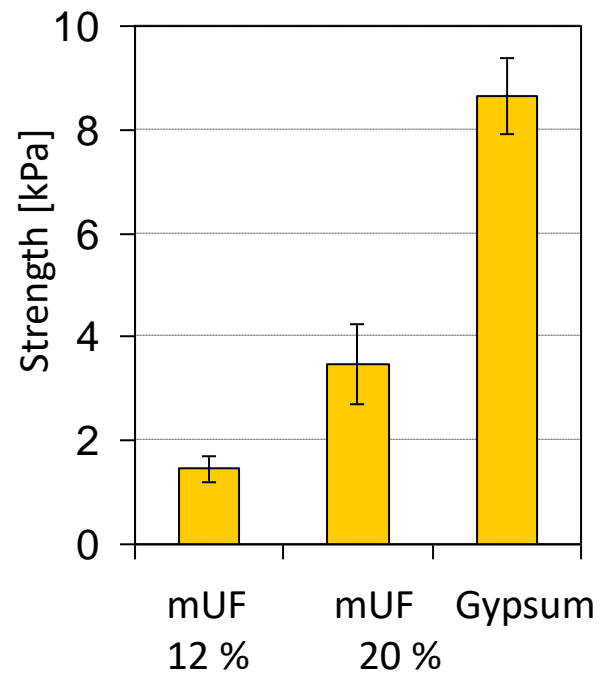
- Disintegrate fabric into fibers
 - Cutting textile waste
 - Garnett machine (carding machine)
- Reclaimed fibers
 - Average fiber length < 10 mm
 - Considerable fraction of dust
 - Residual fabrics
 - Blend of polymers and colors
- Utilization
 - Yarn formation
 - Nonwovens (DE: 95 %)



- Ground flock



- Results (strength; bending fracture test)
 - Strength increases with increasing portion of resin
 - Strength gypsum plaster board higher
 - But: specific strength of mUF-board higher



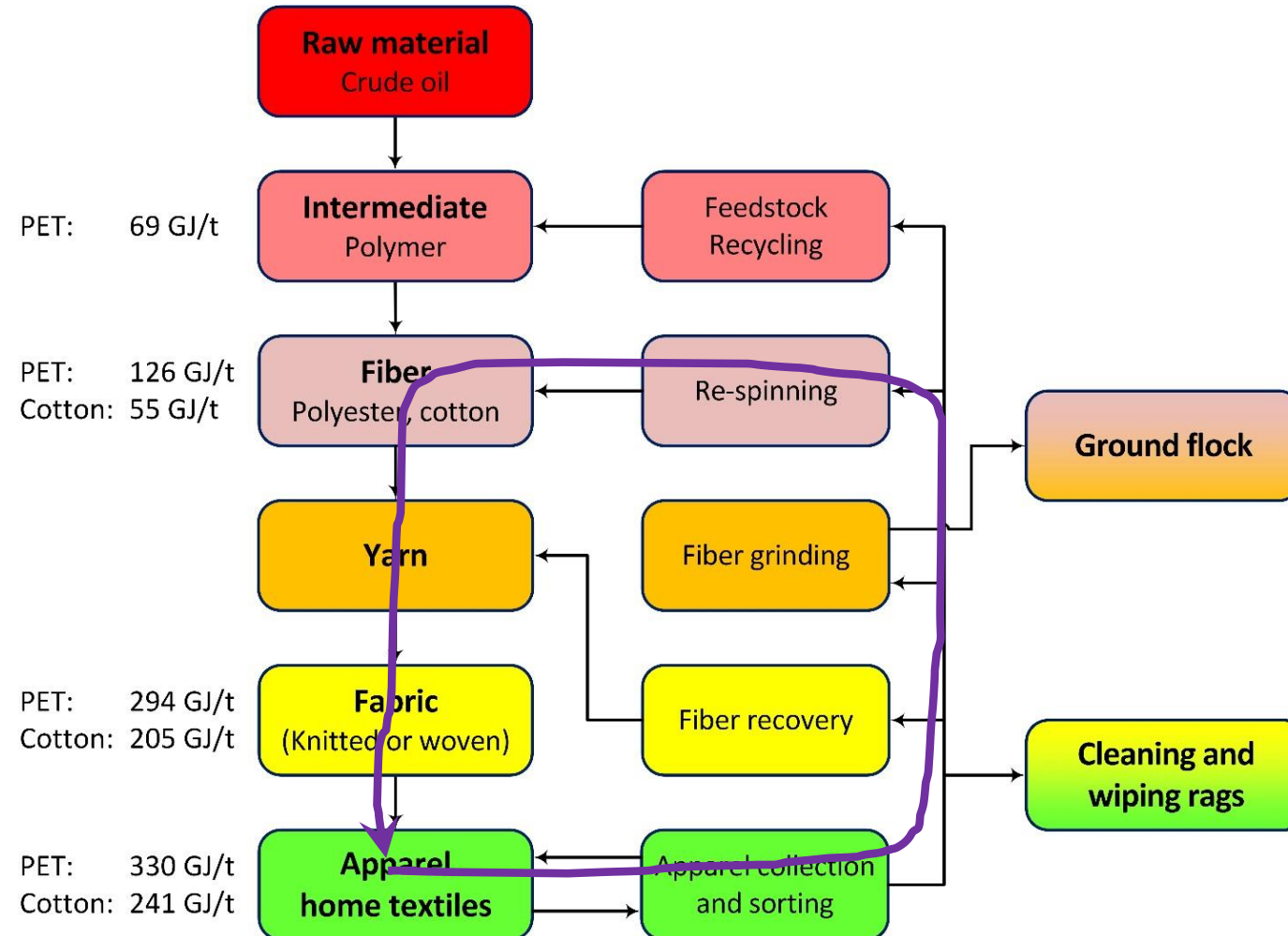
$$R_{\text{spec}} = \frac{R_m}{\rho} \left[\frac{\text{N} \cdot \text{m}}{\text{kg}} \right]$$

R_m Strength [kPa]

R_{spec} Specific strength

ρ Density [kg/m^3]

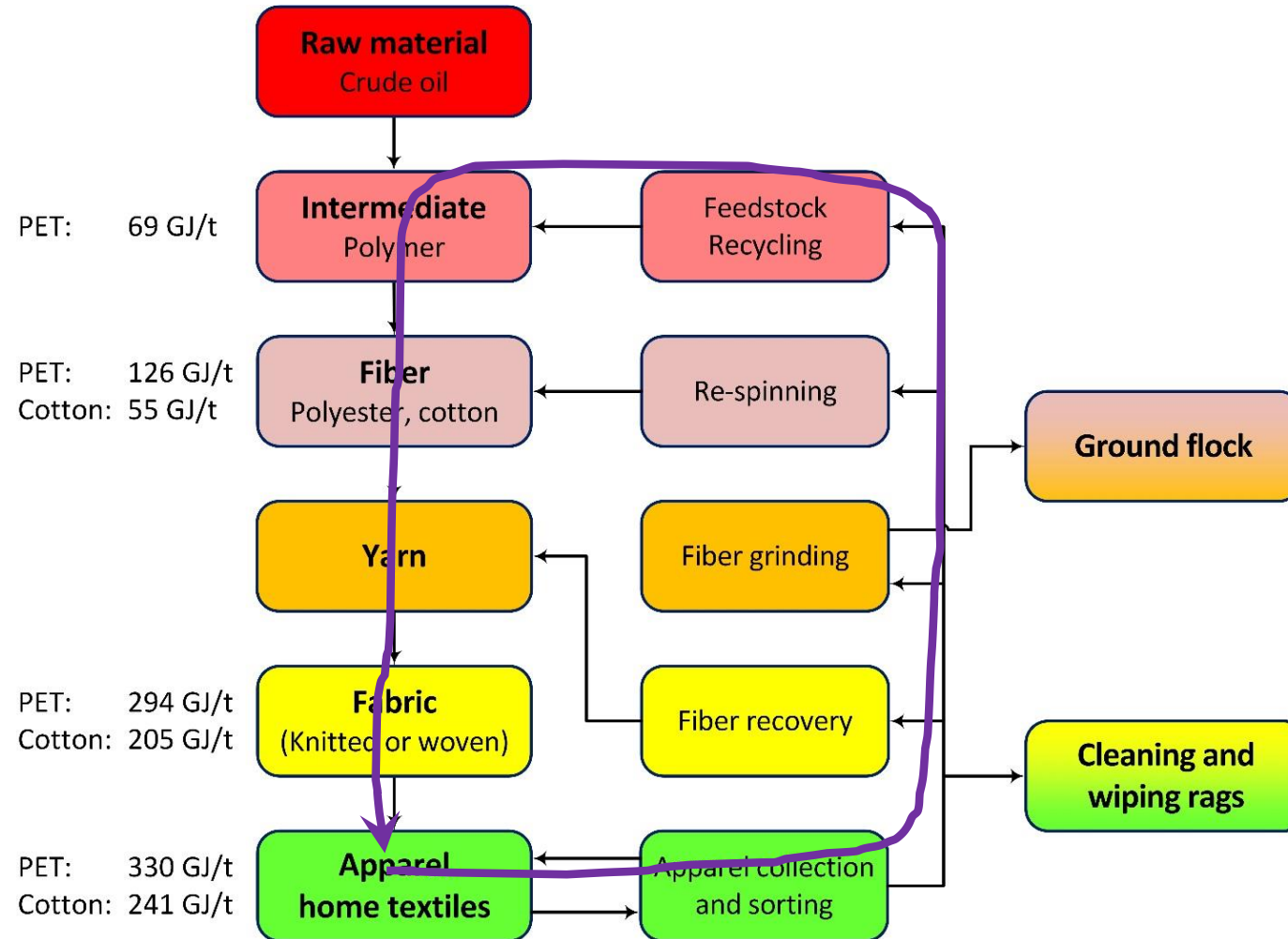
- Re-spinning



- Melting of thermoplast (PET) and fiber spinning
 - B2F
 - 8.2 Mio t collected PET bottles
 - 6.4 Mio t rPET flakes
 - 4.6 Mio t (72%) to fiber industry
 - F2F
- Thermosetting polymers can be dissolved and re-processed
 - Cellulosic fibers (CV, CLY), PAN
- Selective dissolution of cellulosic material
 - NMMO (N-methylmorpholine N-oxide) as solvent
 - PET and other fiber not dissolved
 - 2017: Lenzing AG launched Lyocell production from cotton cutting and trimmings (Refibra[®])

- Simplifying complex mixtures
 - Enzymatic hydrolysis of cotton or man-made cellulosics
 - Residual polyester for recycling
- Research in progress
 - H&M with The Hong Kong Research Institute of Textiles and Apparel (HKRITA)
 - “TEX2MAT”: Austrian project under the lead of the Austrian Chamber of Commerce with 13 partners

- Feedstock recycling



- Pyrolysis, hydrocracking or gasification
 - Broad spectrum of gaseous, liquid and solid products
 - More or less all kinds of textile waste
- Depolymerization
 - Generation of monomers or oligomeres
 - Ionic liquids, enzymes, alcoholysis, hydrolysis, glycolysis or aminolysis,
 - Subsequent de novo polymerization

- Textiles represent a major waste stream
- New legislation
 - Change of collection systems?
 - EPR for textiles?
- Re-use (second-hand clothes)
 - Export to developing countries?
 - How to increase sales in Europe?
- Recycling
 - Tremendous need to improve technology
 - New technologies in the starting blocks
- Circular Economy?
 - Design (increase useful life, reparability, recyclability)
 - Transparency in textile processing chain/circle

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