Recycling contaminants: chemicals in the paper product cycle

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Discussion forum on Life Cycle Assessment

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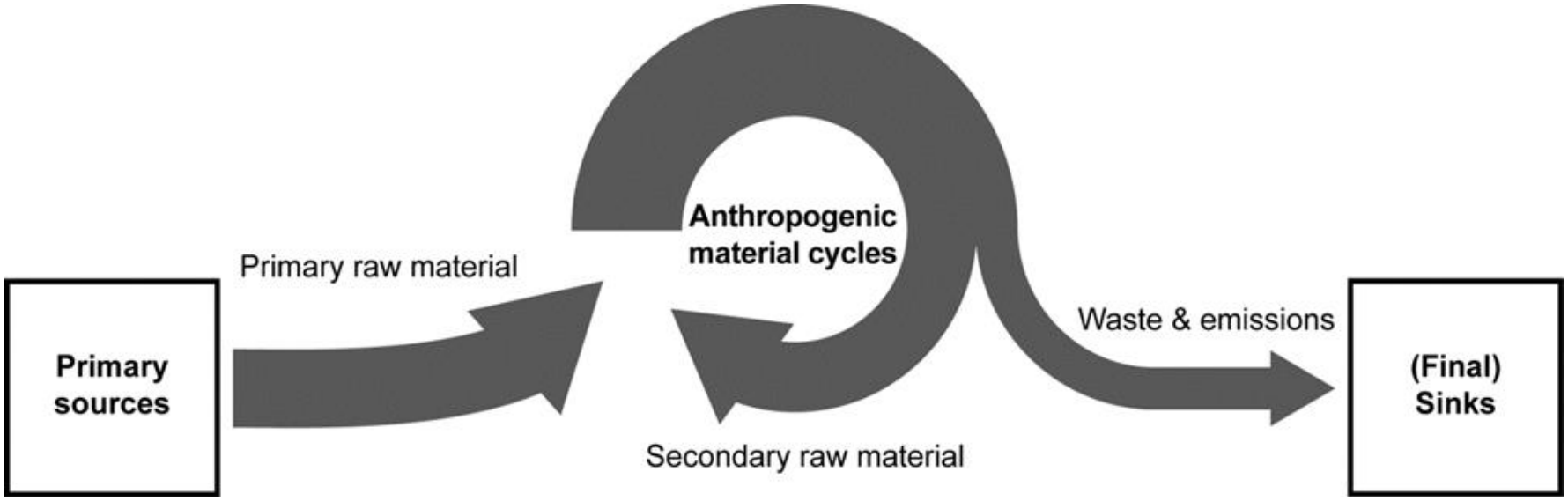
Clean cycles… safe final sinks

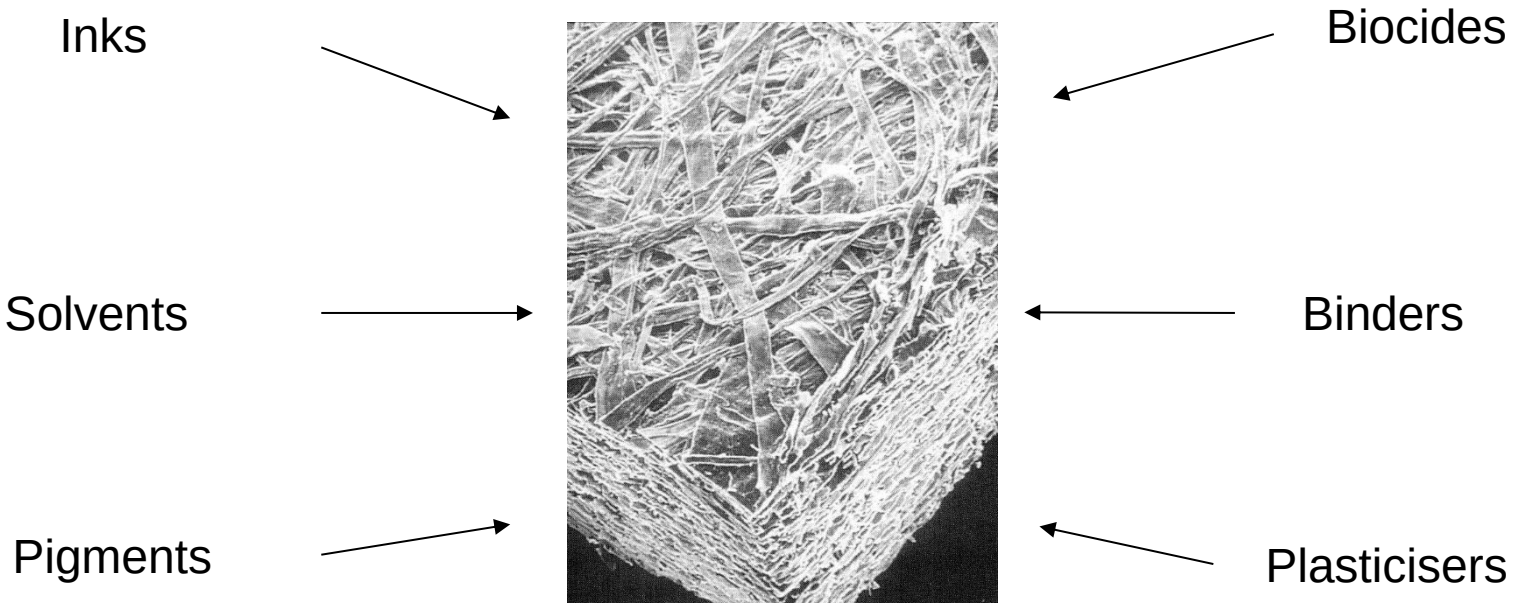


Source:
Laner & Rechberger (2016), doi: 10.1007/978-94-017-7610-3
based on Kral et al. (2013), doi:http://dx.doi.org/10.1016/j.scitotenv.2012.08.094

Paper – not just fibers

- **Paper has a high share of secondary production**

- **Paper is not composed of fibers only**



Source: http://thefiberwire.com

Unwanted cycles

- **Bisphenol A (BPA)**
  - Mainly used in thermal paper (color developer) and also for glueing

Source: Liao & Kannan (2011), doi: 10.1021/es202507f

- **Diethylhexyl phthalate (DEHP)**
  - Used as plasticizers in lacquers, dispersion glues, and printing inks

- **Mineral oil hydrocarbons (MOHs)**
  - Mainly used in offset printing (solvents)
  - Contamination of foodstuff reported

Source: Foodwatch (2015)

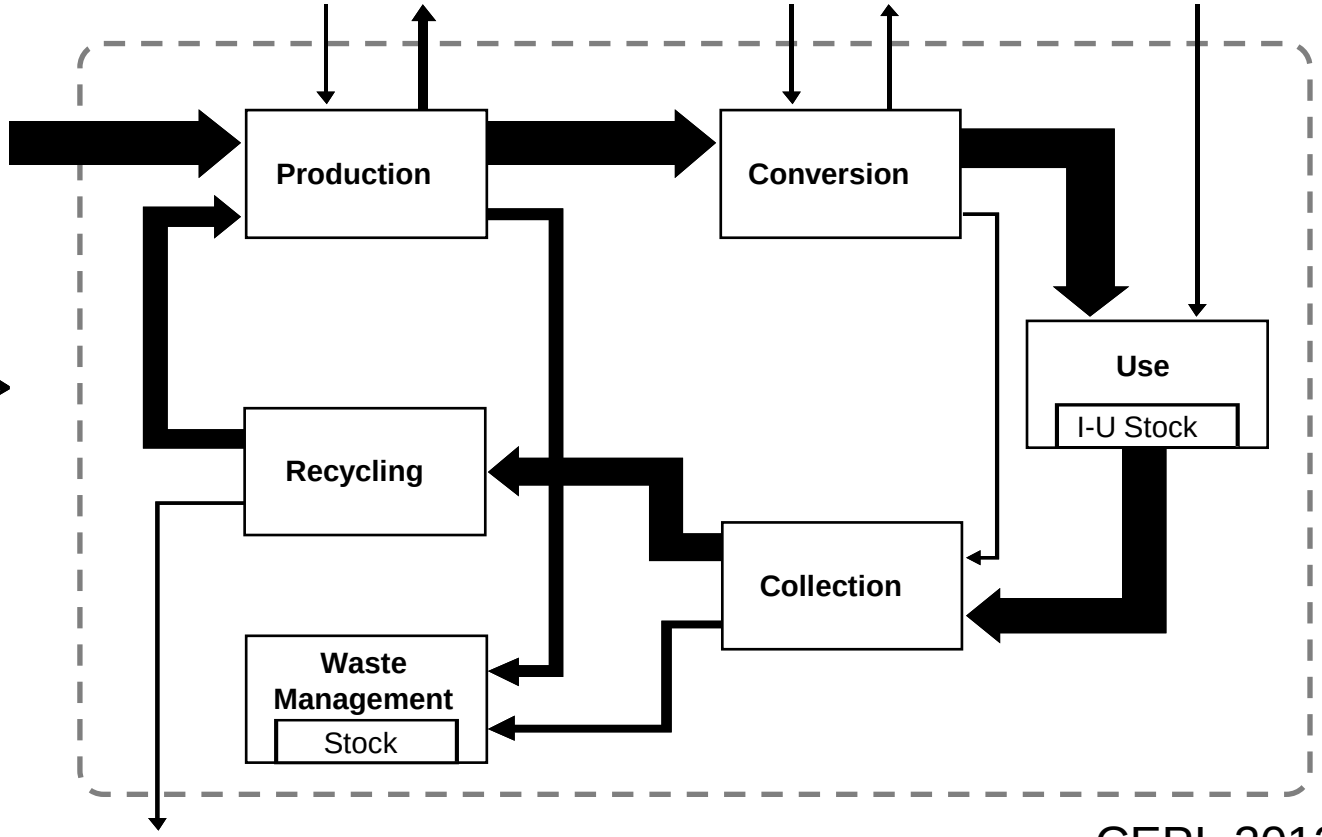
Goal & Approach

- **Goals:**
  - Evaluate the flows of chemicals (BPA, DEHP, MOHs) in circular product systems (given limited data availability) using the example of paper
  - Develop and assess strategies for reducing contamination of paper products with these chemicals

- **Approach**
  - European paper flow budget for the year 2012
  - Determine the amount of chemicals used in paper products
  - Dynamic model of the paper cycle
  - Analyse scenarios for reducing chemicals contamination of paper products

1. Balancing paper flows in Europe (2012)

Input data:
Production statistics, trade statistics, paper collection & recycling, waste management, etc.



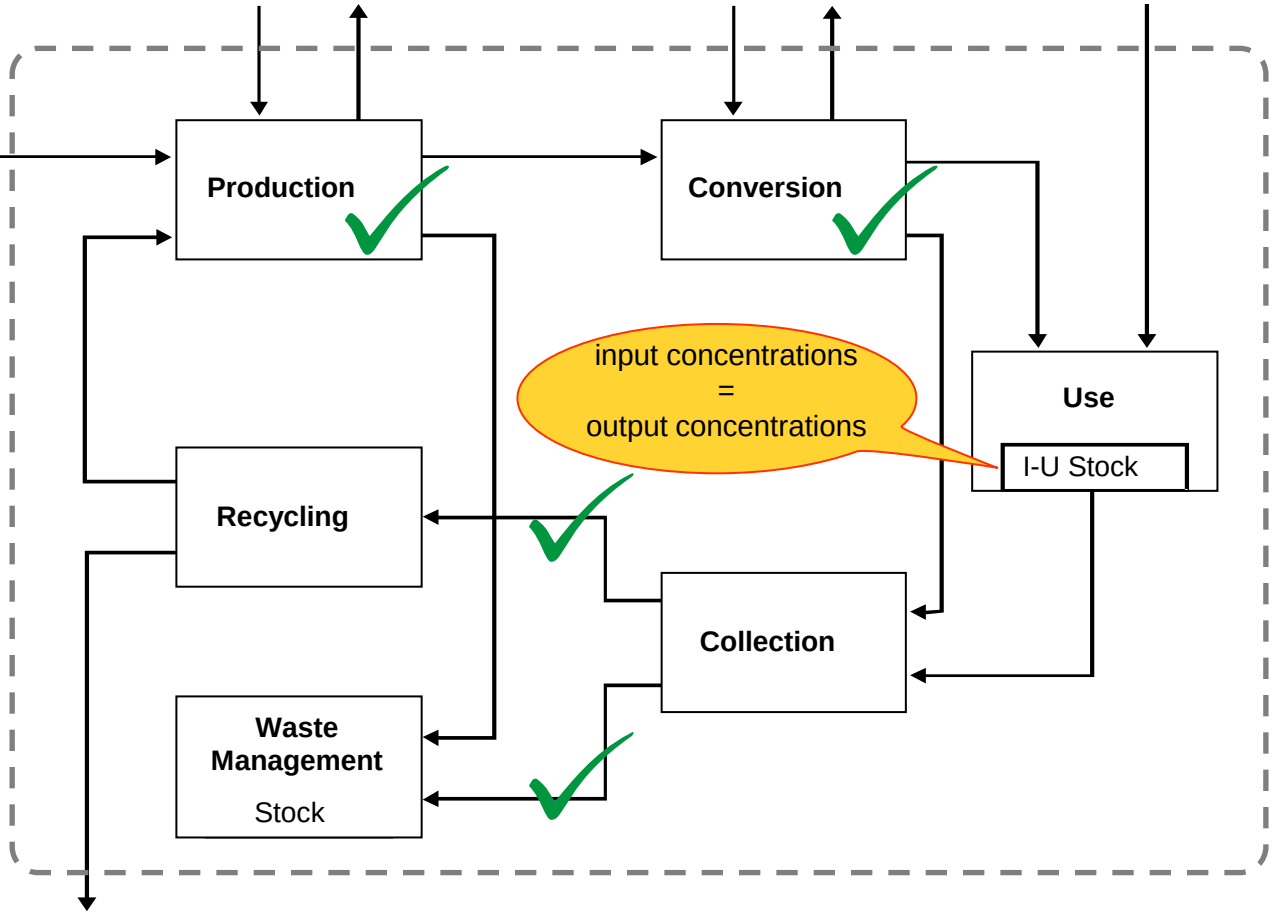
CEPI, 2012

Balanced paper flow system,
Process transfer coefficients
(goods level)

Source:
Pivnenko et al. (2016), doi: 10.1021/acs.est.6b01791.

2. Determining chemicals flows

Input data:
Paper waste chemical analyses, production model & removal efficiencies, paper conversion model.



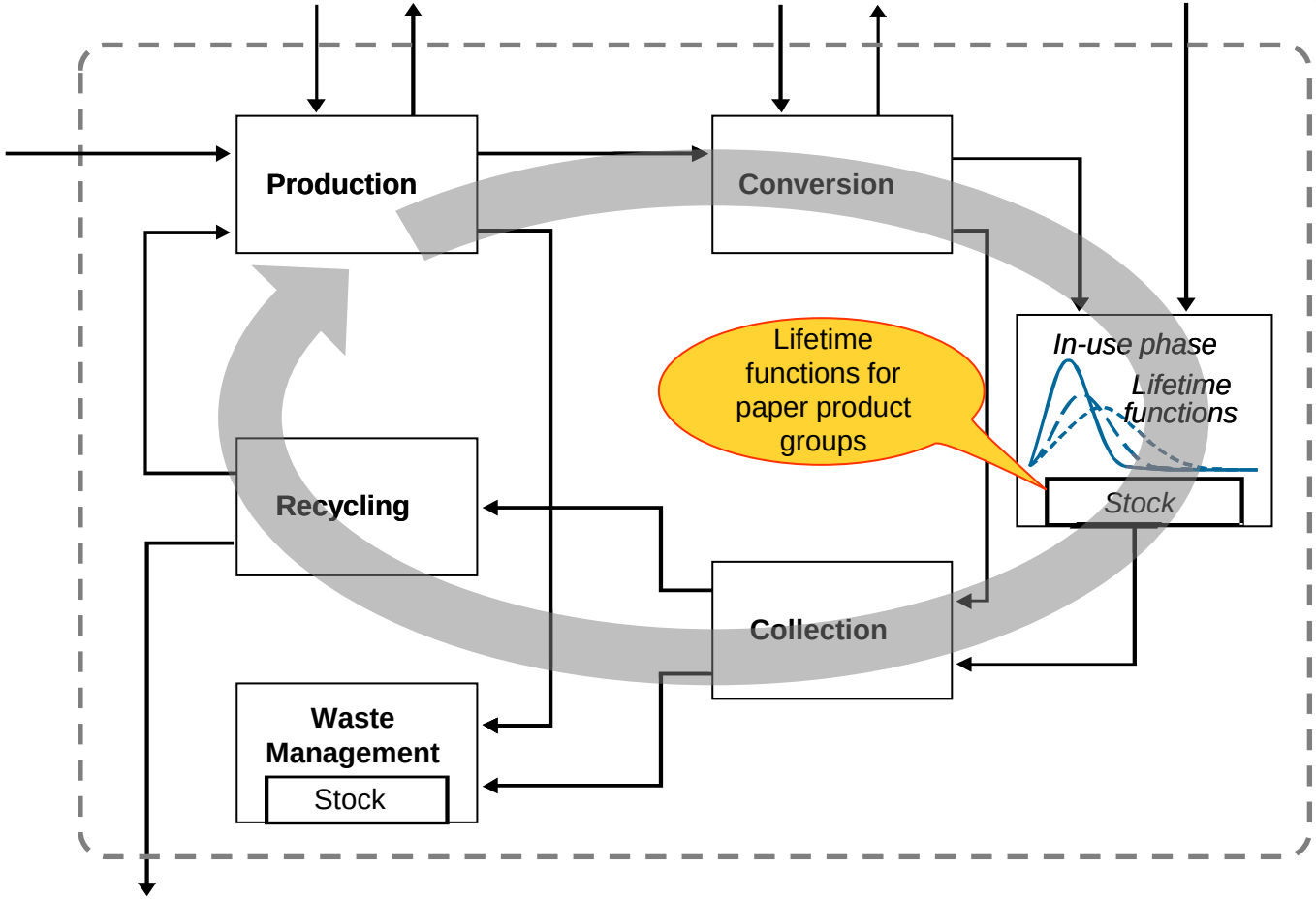
CEPI, 2012

Amounts of **chemicals added** per year, **Process transfer coefficients** (substance level)

Source:
Pivnenko et al. (2016), doi: 10.1021/acs.est.6b01791.

3. Dynamic model of goods & substance cycles

Input data:
Paper production constant (goods level), constant amount of chemicals added every year (substance level), product lifetime functions



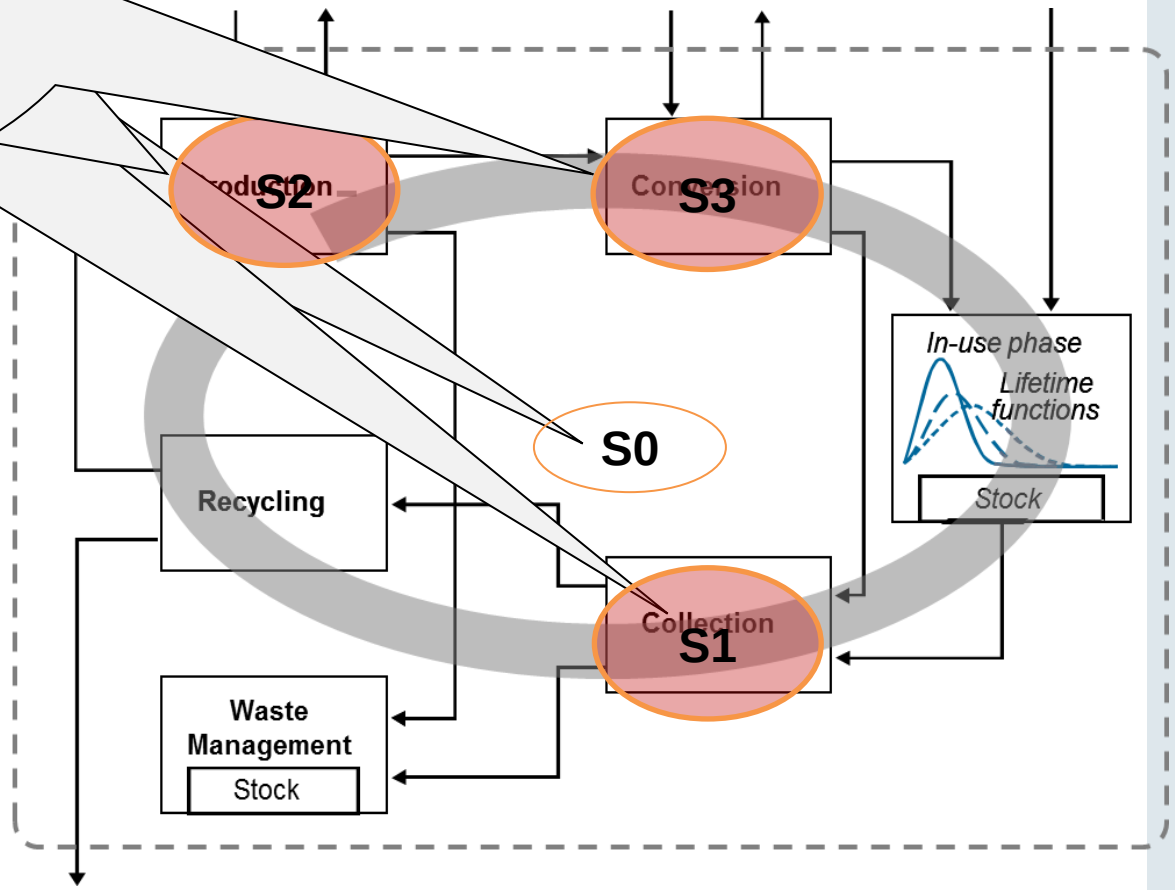
Scenarios to investigate chemical cycles in paper products

Source:
Pivnenko et al. (2016), doi: 10.1021/acs.est.6b01791.

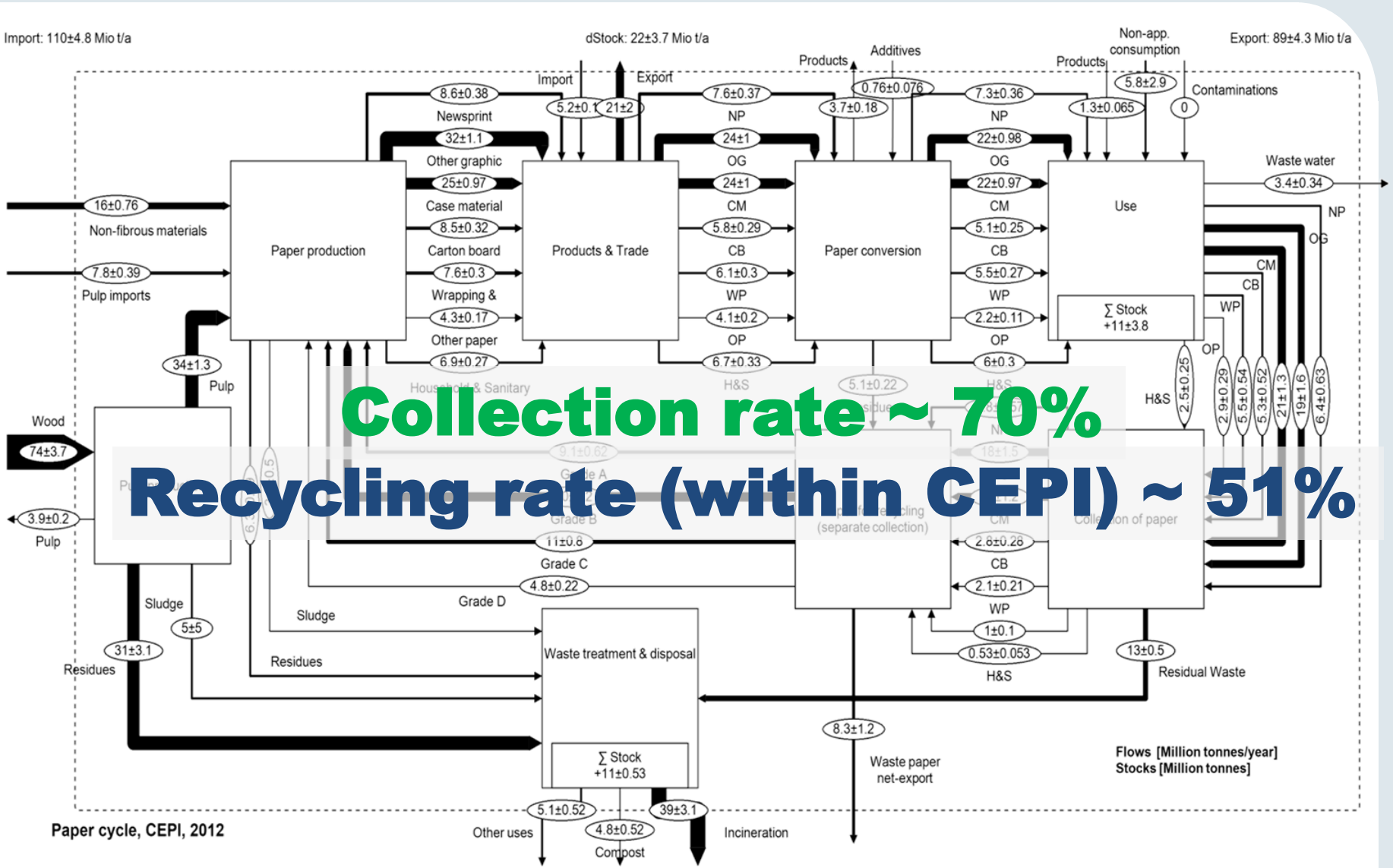
4. Scenario analysis

S3 – Ban of chemical

Phase out of chemicals – Reduction of use to 0 within 5 years

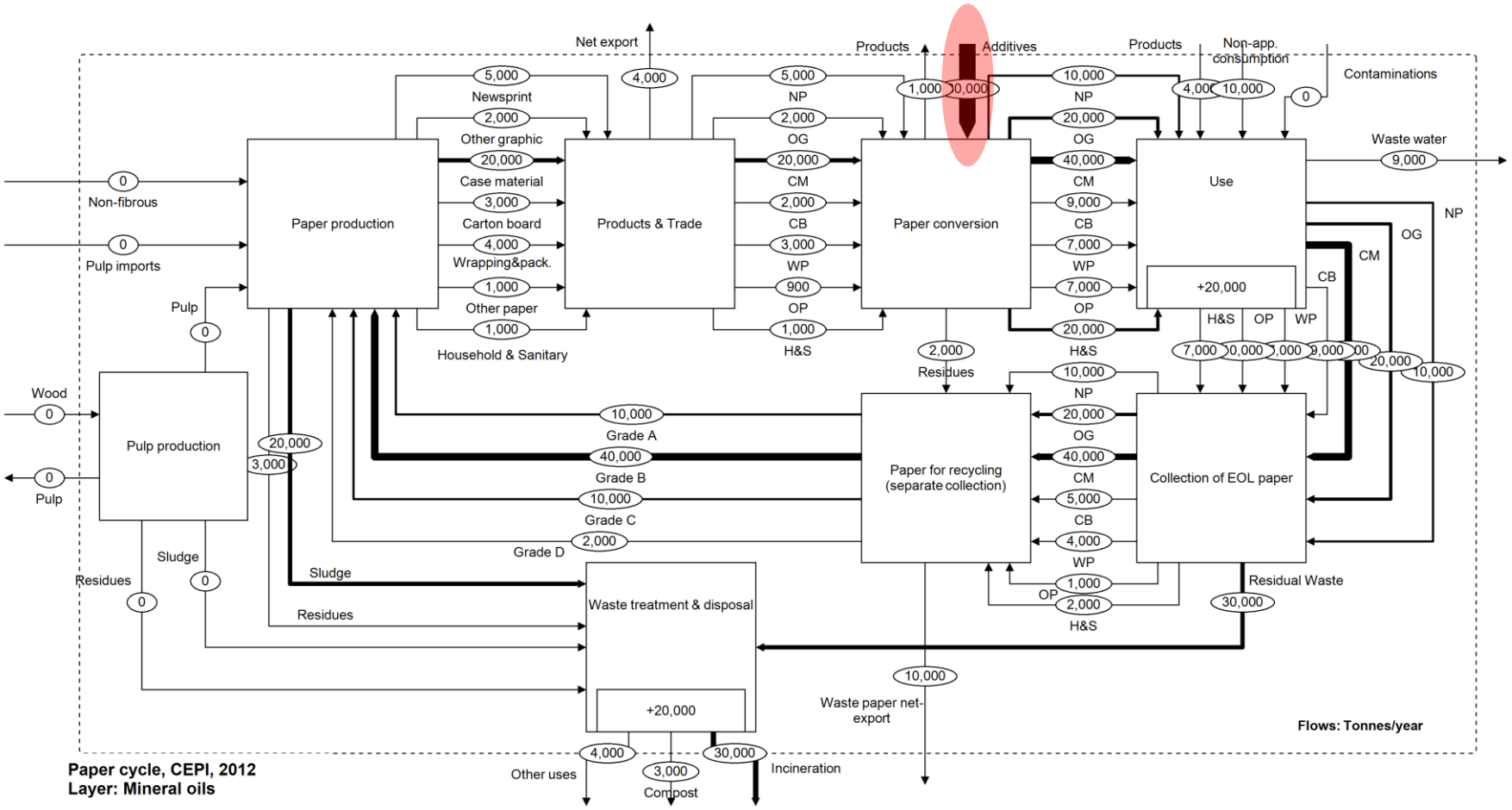


Paper flows in Europe (2012)



Source:
Pivnenko et al. (2016), doi: 10.1021/acs.est.6b01791.

Chemicals flows in Europe (2012)



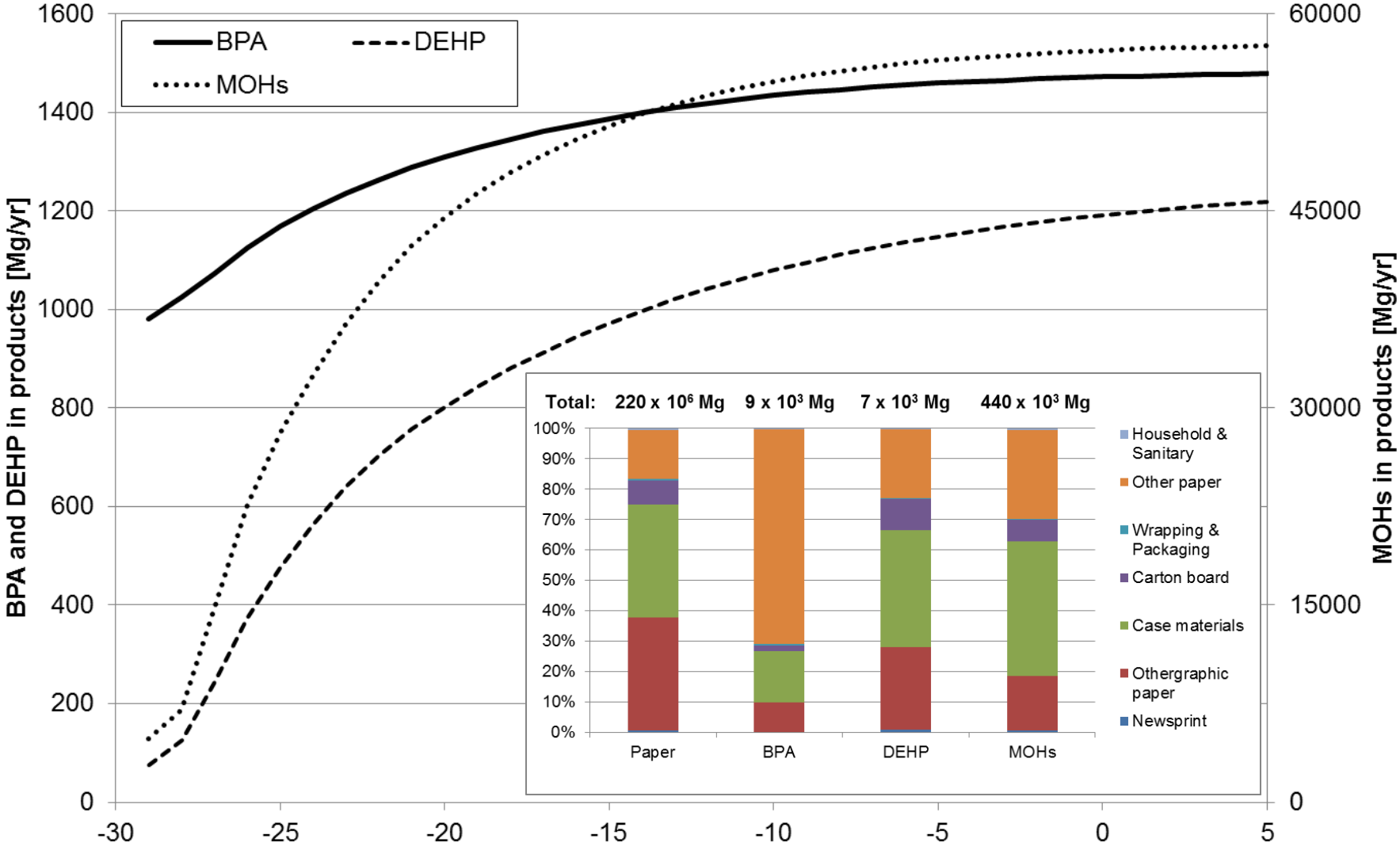
Paper cycle, CEPI, 2012
Layer: Mineral oils

Paper cycle, CEPI, 2012
Layer: Phtalates

Paper cycle, CEPI, 2012
Layer: Bisphenol A

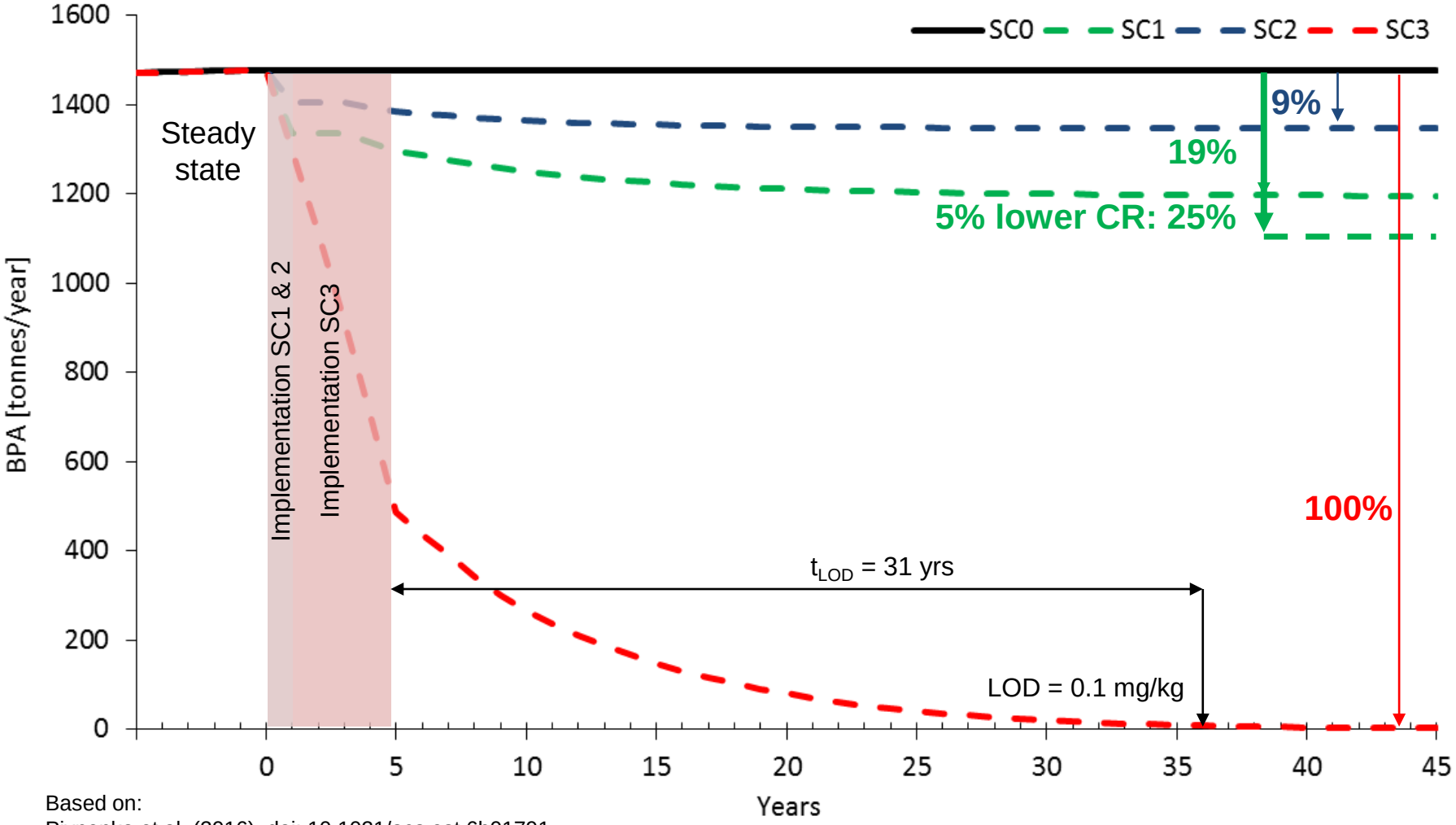
Source:
Pivnenko et al. (2016), doi: 10.1021/acs.est.6b01791.

Dynamic model: Reference scenario



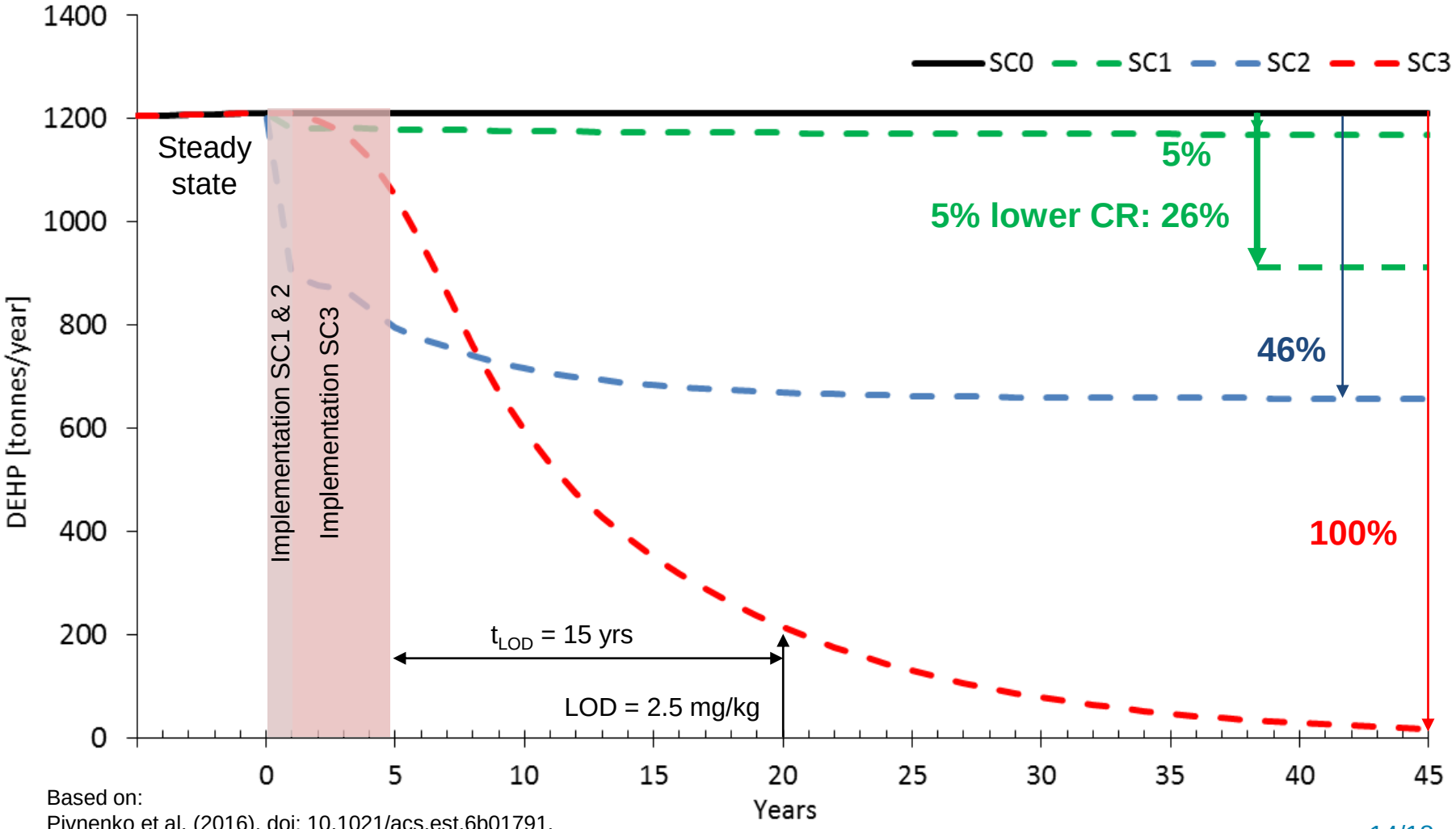
Based on:
Pivnenko et al. (2016), doi: 10.1021/acs.est.6b01791.

Reduction measures: BPA in paper products



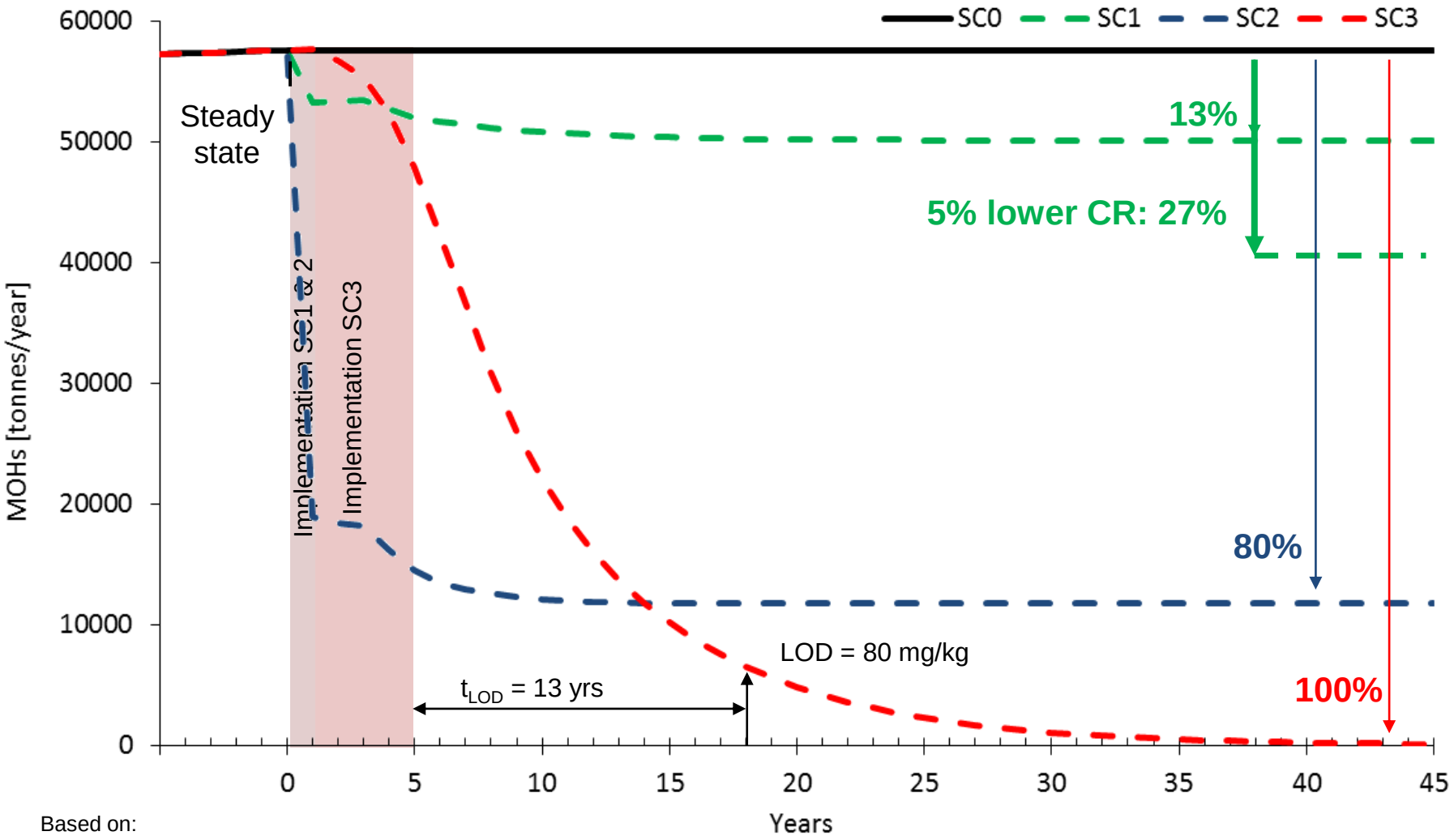
Based on:
Pivnenko et al. (2016), doi: 10.1021/acs.est.6b01791.

Reduction measures: DEHP in paper products



Based on:
Pivnenko et al. (2016), doi: 10.1021/acs.est.6b01791.

Reduction measures: MOHs in paper products



Based on:
Pivnenko et al. (2016), doi: 10.1021/acs.est.6b01791.

Conclusions

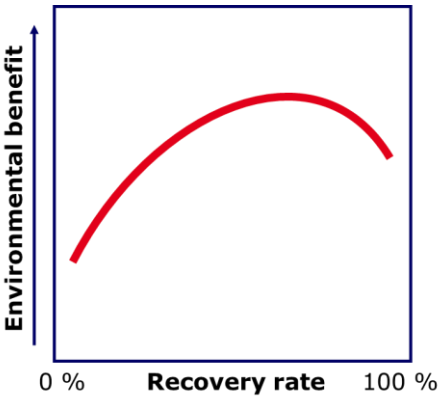
- **Chemicals cycles in paper products**
  - **Didactical case study (assumptions & uncertainties)**
    - Monitoring of contaminants in material cycles
  - **Measures for reducing paper product contamination**
    - **Phase out is most effective** (however, 13-31 years to fall below LOD)
    - **Collection** (at current collection rates) **close to optimum** (low to moderate optimization potential)
    - **5% lower collection rate increases** the potential for **reducing chemicals** content in virgin paper products by optimized collection

→ Trade-off between QUALITY and QUANTITY if waste paper share is (further) increased in paper production

Explore the trade off… using LCA

- **Resource recovery needs to be optimised**
  - quality of the secondary raw material
  - directing pollutants to appropriate sinks
  - substituted products

min(env. Impacts),
max(resource conservation)



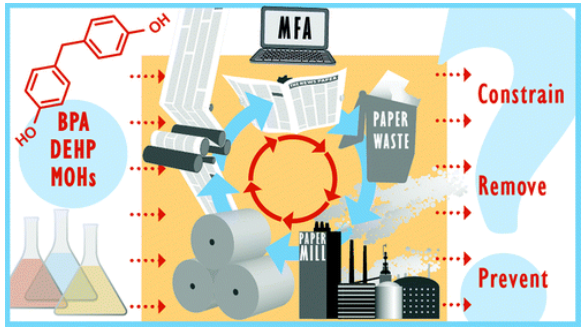
Based on: Laner & Rechberger (2007),
ttp://dx.doi.org/10.1016/j.resconrec.2007.03.004

- **Impact assessment of products as sinks**
  - Link the modelling of substance flows in circular material flow systems to exposure, effect and consequent damage
    - i.e. does increased recycling mean increased risk?

Thank you for your attention!

Reference:

Kostyantyn Pivnenko, David Laner, Thomas F. Astrup (2016): Material cycles and chemicals: Dynamic material flow analysis of contaminants in paper recycling. Environmental Science and Technology, DOI: 10.1021/acs.est.6b01791.



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