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# Environmental impacts of bio-based materials

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# Key research questions

1. Do bio-based materials offer environmental benefits? And how?


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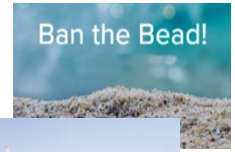
2. For bio-based products: can we avoid potential environmental problem from early-stage development?


3. Impacts of macro, micro and nanoplastics

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# Case 1. BREW (2003-2006)

*Medium and long-term opportunities and risks of the biotechnological production of bulk chemicals from renewable resources*

- **15 years ago…**
- **Techno-economic and environmental assessments of ca. 20 basic bulk chemicals: "Today" vs "Future"**
- **Cradle-to-factory gate "white biotechnology".**

## Findings

- Clear opportunities for NREU and GHG emission reduction
- Under favourable conditions: esp. bio-based ethylene

BREW report: https://dspace.library.uu.nl/bitstream/handle/1874/21824/NWS-E-2006-146.pdf?sequence=1

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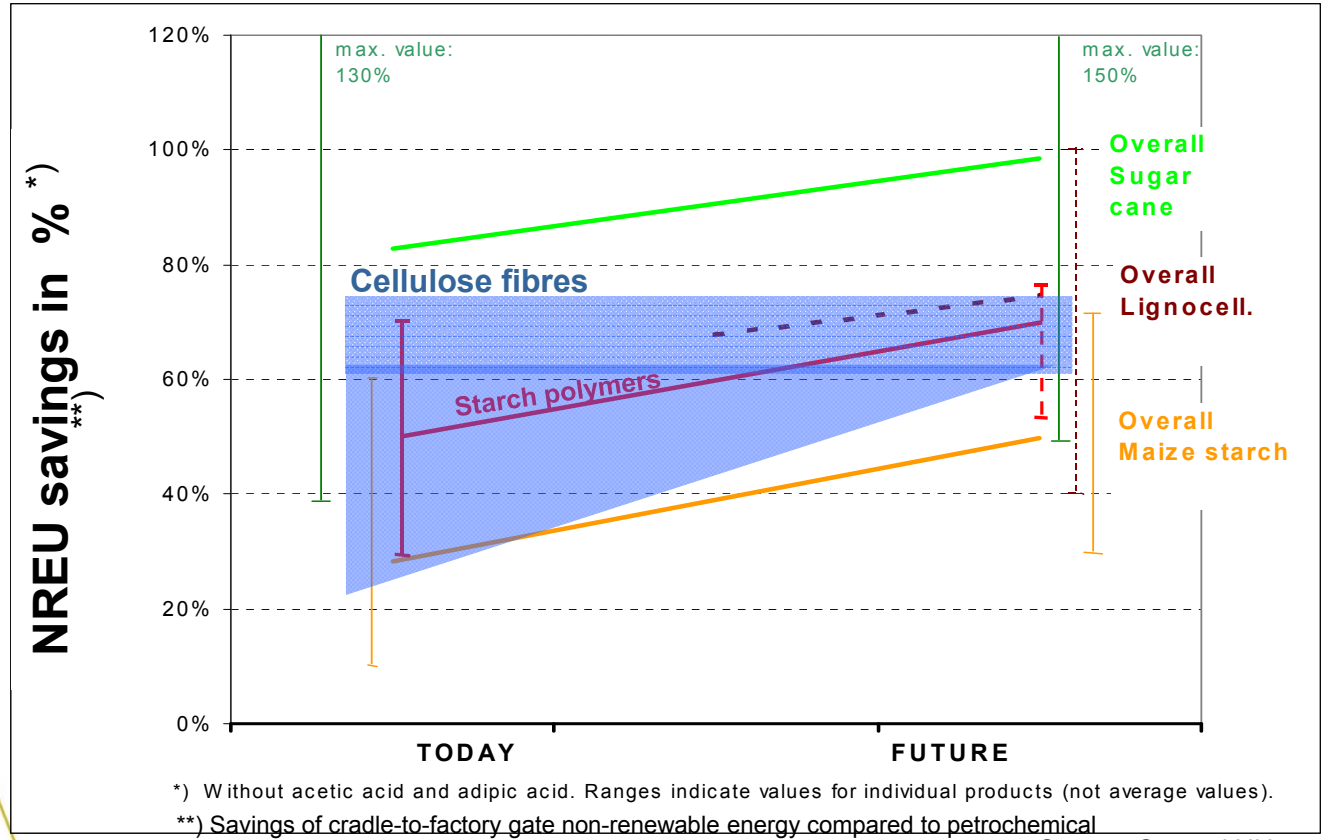
# Non-renewable energy use (cradle-to-factory gate) for White Biotechnology products and other bio-based products versus petrochemical products




Source: Several UU studies, among them BREW

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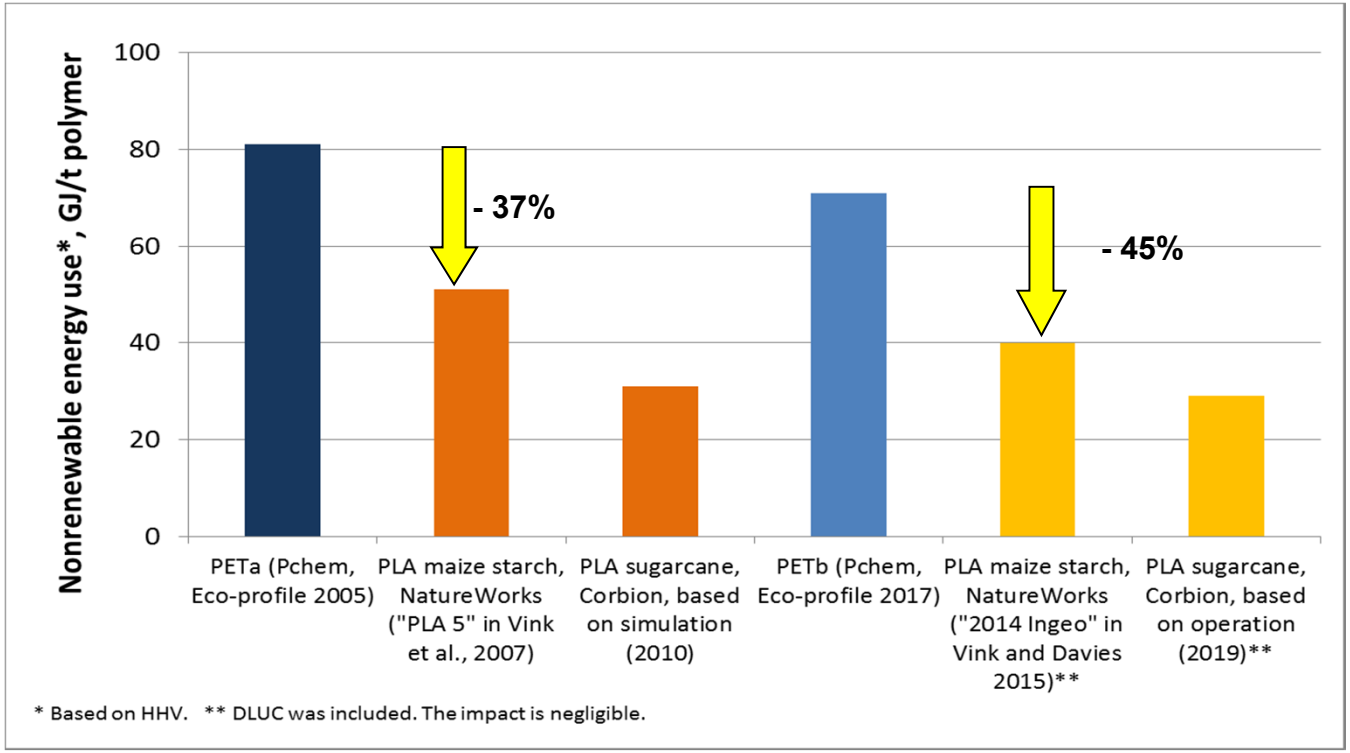
# Where do we stand today?

## Polylactic acid (PLA)
## Non-renewable energy use, cradle-to-factory gate



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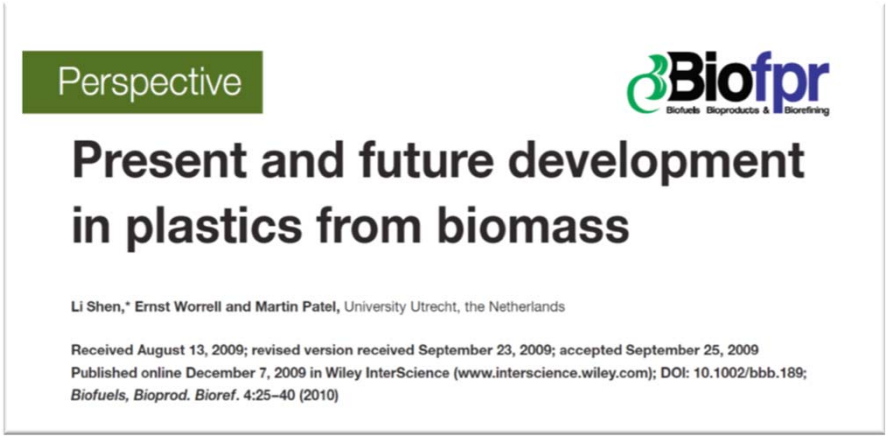
# Case 2. PRO-BIP study (2007-2009)

*Product overview and market projection of emerging bio-based plastics*

- Current Market Volumes
- Technical substitution potentials
- 2020 Market projections of bio-based plastics


Perspective

Biofpr
Biofuels Bioproducts & Biorefining

**Present and future development in plastics from biomass**

**Li Shen,* Ernst Worrell and Martin Patel,** University Utrecht, the Netherlands

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**Published online December 7, 2009 in Wiley InterScience (www.interscience.wiley.com); DOI: 10.1002/bbb.189;**
***Biofuels, Bioprod. Bioref*. 4:25–40 (2010)**

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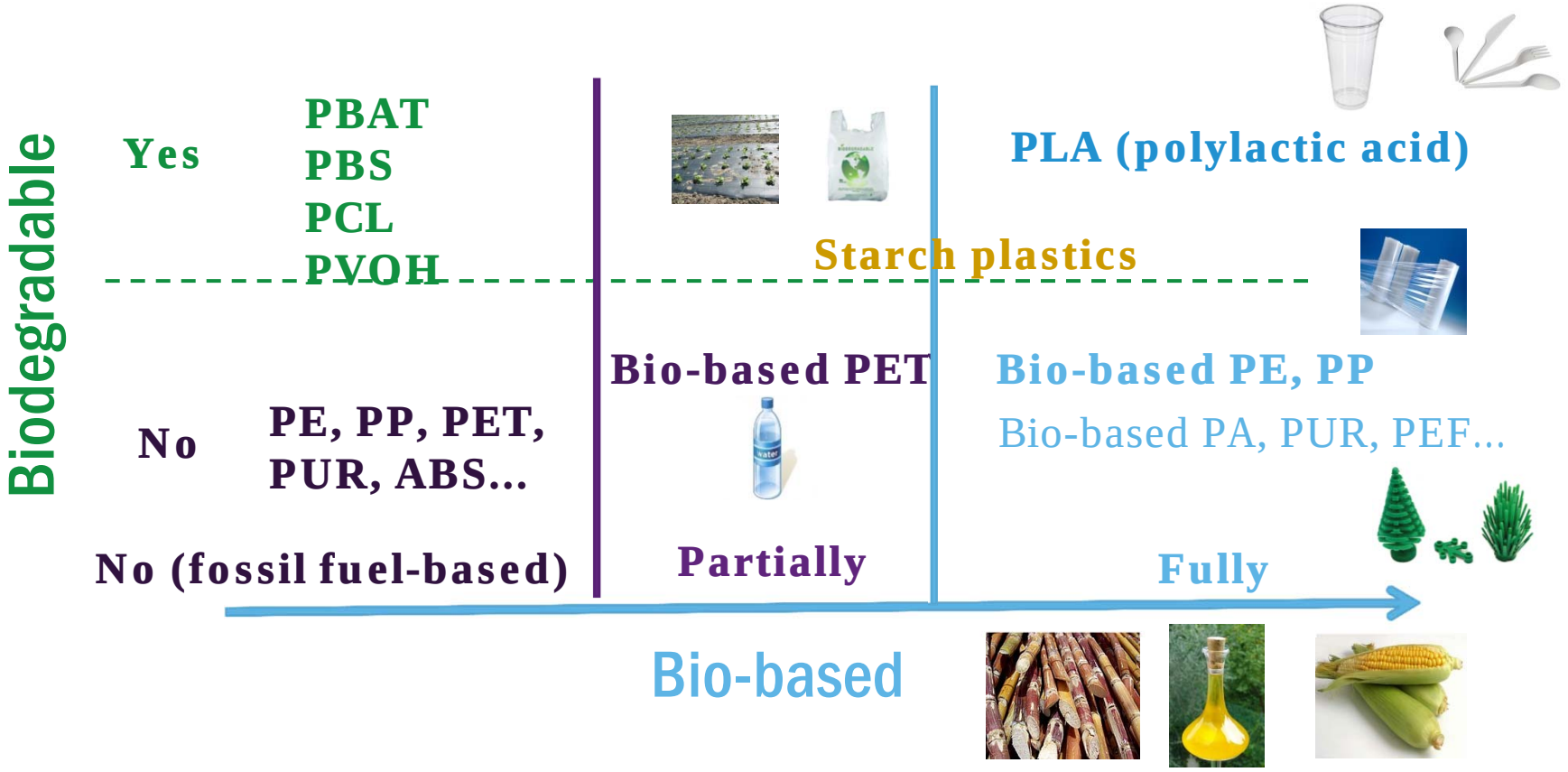
# Can bioplastics provide an solution?

What is "bioplastics"?



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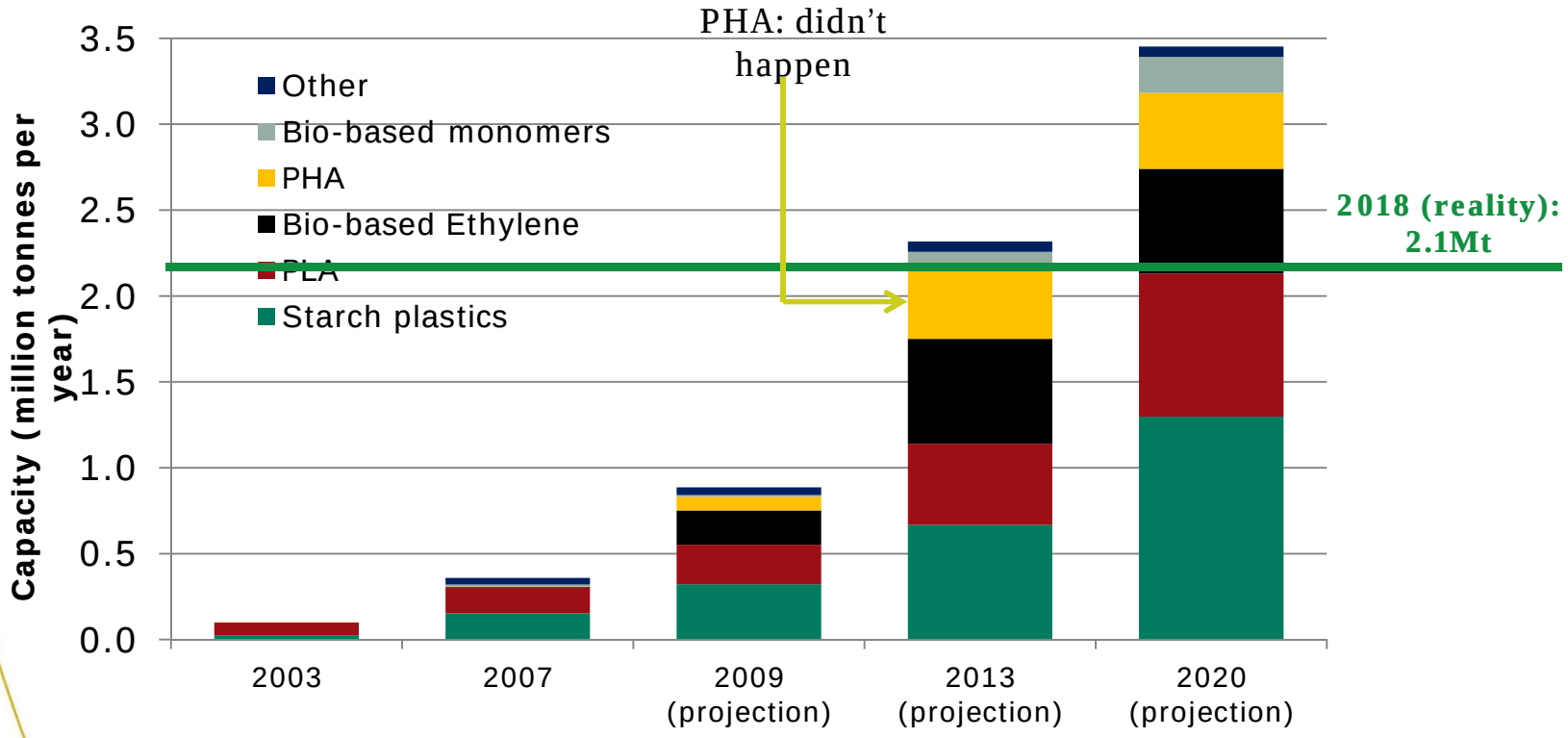
# Projection of Worldwide bio-based plastics capacity 2020




Note: Category "other" includes cellulose films, PTT from bio-based 1,3-PDO,bio-based polyamide and PUR from bio-based polyols; category "Bio-based monomers" includes primarily bio-based epichlorohydrin.

# Case 3. PET recycling (2009-2011)

- Bottle-to-fiber recycling:
  - Mechanical recycling
  - Semi-mechanical recycling
  - Chemical recycling
- Various allocation methods ("Cut-off", "Waste valuation", "System expansion")
- Compare: recycled PET, bio-based PET and recycled bio-based PET?

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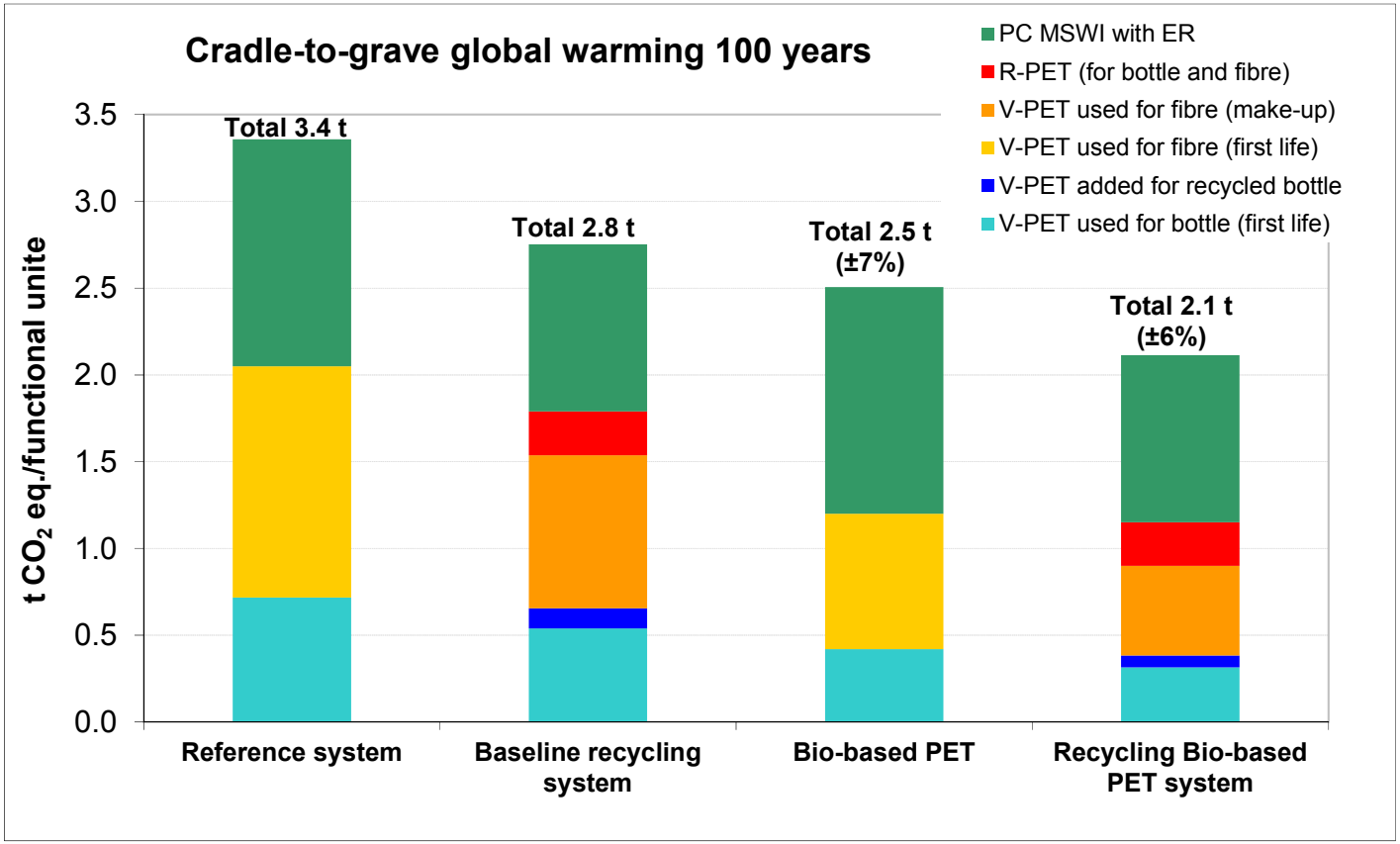
# PET recycling systems: Comparing the biobased and the recycled




Shen, L., Worrell, E., & Patel, M. K. (2010). *Resources, Conservation and Recycling*, *55*(1), 34–52.

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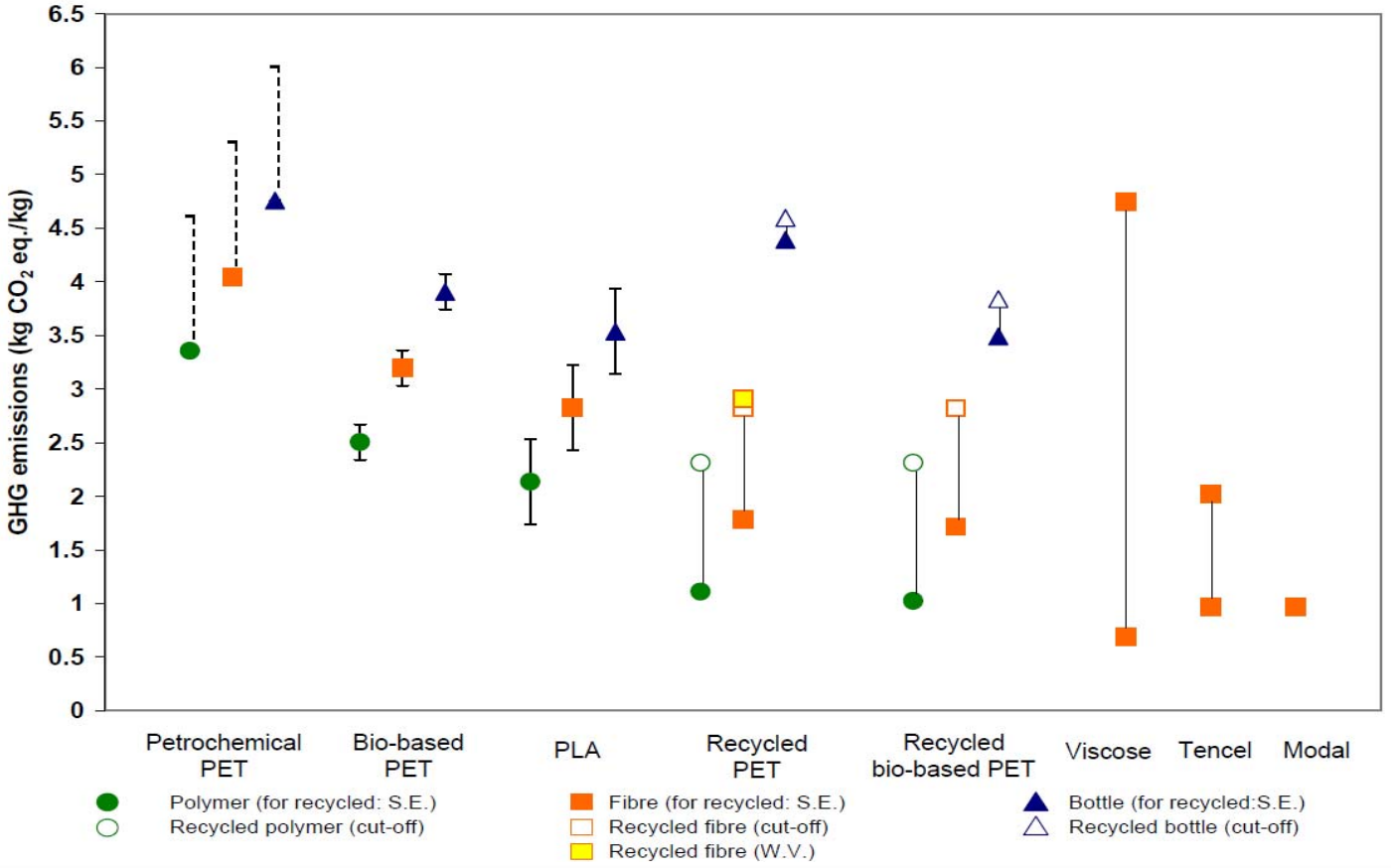
# Cradle-to-gate GHG emissions of polymers, fibre and bottles



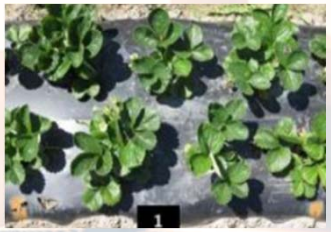



Shen, L., Worrell, E., & Patel, M. K. (2012). *Biofuels, Bioproducts and Biorefining*, *6*(6).

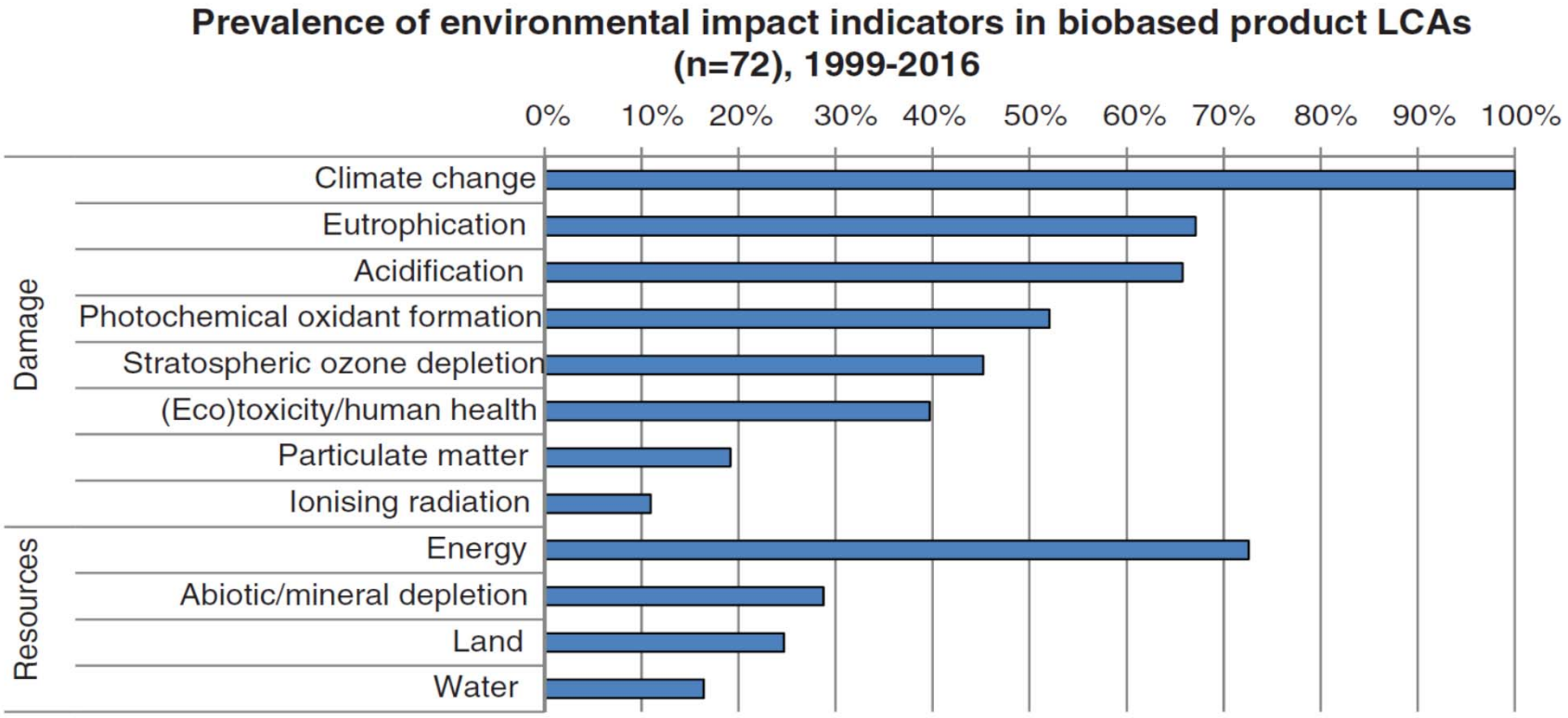
# BIO-SPRI project (2017-2018): Environmental impacts of bio-based plastics

Seven Life Cycle Assessment (LCA) case studies :

- Beverage bottles (PET)
- Horticultural clips (Starch plastics)
- Single-use drinking cups (PLA)
- Single-use carrier bags (Starch plastics)
- Food packaging films (PLA)
- Single-use cutlery (PLA)
- Agricultural mulch films (Starch plastics)

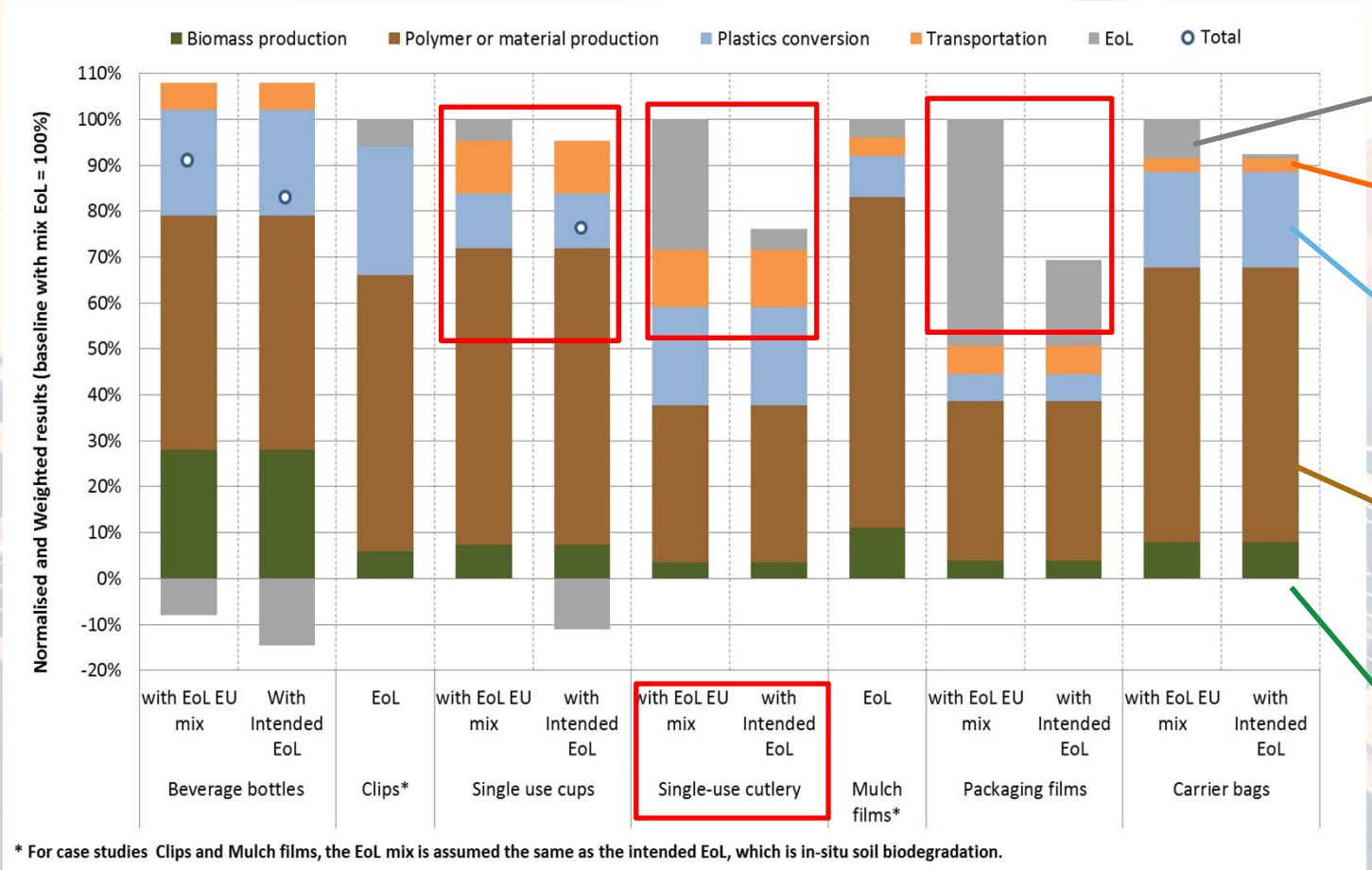







Broeren, M. L. M., Zijp, M. C., Waaijers-van der Loop, S. L., Heugens, E. H. W., Posthuma, L., Worrell, E., & Shen, L. (2017).. *Biofuels, Bioproducts and Biorefining*, *11*(4), 701–718.

# BIOSPRI project: What did we find out?




* For case studies Clips and Mulch films, the EoL mix is assumed the same as the intended EoL, which is in-situ soil biodegradation.

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# The “whale” in the room:

## Can bioplastics contribute to a sustainable circular economy?