Universiteit Utrecht

COWI

Copernicus Institute of Sustainable Development

Life Cycle Assessments of seven innovative bio-based products

BIO-SPRI Task 1

Dr. Li Shen, Utrecht University

6 June 2018, Brussels

Photo UU

Aim of the study

"Support to Research and Innovation Policy for Bio-based Products"

Task 1 – goal of the LCA: "Provide science-based evidence to support policy decisions"

- Identify the key environmental **hotspots** of **innovative** bio-based plastics
- **Compare** the environmental impacts with the fossil fuel-based counterparts

Exclude: the conventional bio-based products...

Universiteit Utrecht

Selection of the case studies

5 Criteria, 16 sub-criteria

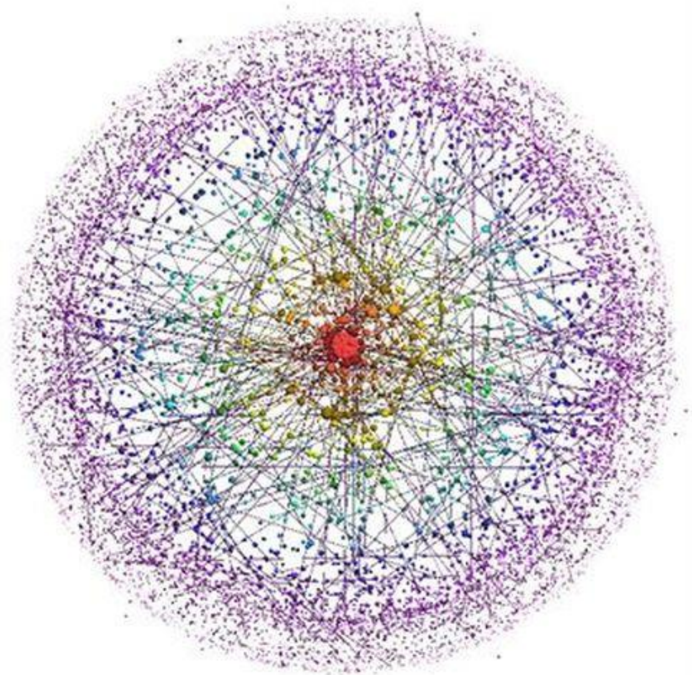
- Market potential
- Promise for deployment
- Available LCA data
- Innovation
- Potential sustainability benefits

Seven case studies :

- Beverage bottles
- Horticultural clips
- Single-use drinking cups
- Single-use carrier bags
- Food packaging films
- Single-use cutlery
- Agricultural mulch films

Life Cycle Assessment

"Best framework for assessing the potential environmental impacts of products" (COM (2003)302)



Picture courtesy to Dr. Blanca Corona Bellostas

- As close as the PEF (EC, 2013) and PEFCR guidance (v.6.3)
- Geographical: products sold, consumed and disposed of in Europe
- Technological: established technologies (TRL 9)
- Temporal: Status-quo, 5-10 years into future
- 16 Impact assessment categories

Beyond the PEFCR guideline :

- NREU (Cumulative primary energy, non-renewable)
- GTP (end-point indicator of climate change)
- **Effects of DLUC and ILUC**

Universiteit Utrecht

COWI

Overview of the case studies

Status-quo average technology mix; primary data from industry.

[illegible]	Bio-based baseline	Bio-based alternatives	Reference system(s)
[illegible]	30% bio-based PET	30% PET from different biomass feedstocks	PChemPET
[illegible] use drinking cups	PLA	PLA from different feedstocks, bio-based PP from UCO	PET PP
Single-use cutlery		n/a	PS
Food packaging films		PLA from different feedstocks, bio-based PP from UCO	PP
Horticultural clips	Starch plastics	Starch plastics using different starch sources	PP
Agricultural mulch films		n/a	LDPE
Single-use carrier bags		Bio-based LDPE	LDPE

PET=polyethylene terephthalate; PLA=Polylactic acid, UCO=Used cooking oil, PP=polypropylene, PS=polystyrene, LDPE=low-density polyethylene
PChem=petrochemical

Universiteit Utrecht

COWI

End-of-life challenges

Case studies (baseline vs. ref.)	(Est.) Current EOL for the bio-based (av. EU mix)	Intended EOL	Current EOL PChem reference (av. EU mix)
Beverage bottles (bio-based vs. Pchem. PET)	Recycling, MSWI and landfilling	Recycling	Recycling, MSWI and landfilling *
Single-use drinking cups (PLA vs. PET, PP)	Recycling, Composting MSWI, landfilling	Recycling and/or composting	
Single-use cutlery (PLA vs. PS)			
Food packaging films (PLA vs. PP)			
Horticultural clips (Starch plastics vs. PP)	In-situ soil biodegradation	In-situ soil biodegradation	
Agricultural mulch films (Starch plastics vs. LDPE)			
Single-use carrier bags (Starch plastics vs. LDPE)	Composting, MSWI and landfilling	Composting	

- Niche applications and Status-quo?
- Littering?

*Ratios are different based on different applications

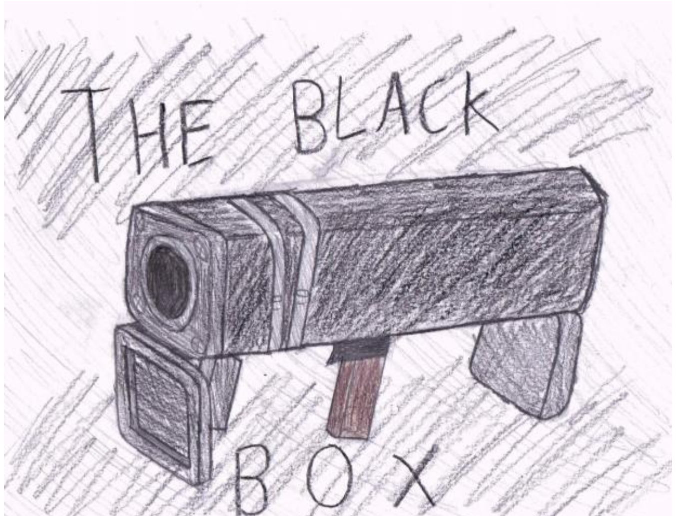
Universiteit Utrecht

COWI

What to compare?

Benchmark: PlasticsEurope's Eco-profiles for PET, PP, LDPE, PS.

1. Imbalanced comparison:
   - European technology mix
   - Comparing with Blackboxes
2. Can all 16 categories be comparable?
   - Literature review: independent LCI data sources?



Picture credit: CrisperTheCat

Highlight of the findings (1/3)

From cradle to grave, based on the seven case studies:

Biomass cultivation:

- Overall is not the most important contributor in most impact categories.
- High contributions in land use, water use, particular matter and eutrophication in many cases, but very much location dependant.
- DLUC and ILUC effects are strongly location dependent

Material and product manufacturing:

- In many cases represents the life cycle stage with the highest impacts.
- Impacts highly associated with energy requirements, sometimes largely determined by plastics conversion steps.

End-of-life:

- Overall seems less important compared to the cradle to factory gate impacts
- Both recycling and MSWI can contribute to a reduced impact.

Highlight of the findings (2/3)

- Out of 16 PEFCR impact categories, only half are recommended to be used for comparison
- Cradle to grave baseline results excluding DLUC and ILUC effects, environmental impact reduction on median values (with ranges):

Lower	Climate change (GWP 100a)	-27%	(-85% to 2%)
	Abiotic depletion (fossil fuels)	-30%	(-70% to -5%)
Inconclusive	Photochemical Ozone formation	4%	(-80% to 73%)
	Particular matter	99%	(-17% to 600%)
	Acidification	63%	(-55% to 120%)
	Terrestrial eutrophication	50%	(-77% to 120%)
	Marine eutrophication	73%	(-57% to 300%)

Highlight of the findings (3/3)

Does PEFCR guidance work well?

Yes – it does in most cases, but

- Niche applications have no clear ‘average mix’
- Littering remains unsolved
- Data asymmetries for comparative purposes
- For constraint resources: macro-level decision context is required

Afternoon session Task 1

Use one case study to demonstrate our work in Task 1: Single-use drinking cups

1. Cradle to user LCA (C. Moretti, UU)
2. Comparing the bio-based with the PChem (Dr. L. Shen, UU)
3. Effects of land use changes (Dr. L. Hamelin, Hamelinlab/COWI)
4. Modelling of End-of-Life (L. Høibye, COWI)

Acknowledgements

- All industrial partners supported this project
- JRC: Dr. Davide Tonini, Dr. Rana Pant (esp. for the debates)

- BIO-SPRI Task 1 Team:
  - **UU**: Dr. Li Shen, Dr. Iris Vural-Gursel, Christian Moretti, Juraj Petrik, Prof. Dr. Martin Junginger
  - **COWI**: Linda HØibye, Dr. Lorie Hamelin, Line Jakobsen, Maria Steingrimsdottir, Dr. Louise Dreyer, Asger Olesen and all the COWI supporting staff