LCA of biopolymers – SYNPOL case study
AGENDA

1. LCA methodology
2. Biopolymers – definition and examples
3. Biopolymers – life cycle and examples (incl. SYNPOL)
4. Conclusions
LIFE CYCLE ASSESSMENT (LCA)

- Cradle-to-grave (incl. waste treatment)
- Cradle-to-gate (certain point, e.g. factory gate)
- Cradle-to-cradle (incl. recycling)
- Gate-to-gate (limited part)

- Guidelines
  - ISO 14040/14044
  - ILCD Handbook

- Standard methodology
  - ILCD 2011 Midpoint+
  - ReCiPe Midpoint & Endpoint
  - IPCC 2013

- Ecoinvent database
LCA EXAMPLE

- What do we want to know?
  - Functional unit (FU): 5 pancakes

- What are in- and outputs?
  - Data inventory throughout the life cycle (preparation, baking, etc.): flour, eggs, milk, heat, CO₂ emissions, …

- What is the impact on the environment?
  - Just climate change
  - or 16 impact categories

- Reference scenario
  - Functional equivalent (e.g. fruit salad)
### IMPACT CATEGORIES

<table>
<thead>
<tr>
<th>Effect category</th>
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<tbody>
<tr>
<td>Climate change</td>
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<tr>
<td>Ozone depletion</td>
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<tr>
<td>Human toxicity, non-cancer effects</td>
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<tr>
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<tr>
<td>Particulate matter</td>
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<tr>
<td>Ionizing radiation HH</td>
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<td>Ionizing radiation E</td>
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<td>Photochemical ozone formation</td>
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<td>Mineral, fossil &amp; renewable resource depletion</td>
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</tbody>
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Climate change impact of 5 pancakes

- Milk: 130 kg CO₂ eq
- Eggs: 105 kg CO₂ eq
- Heating: 70 kg CO₂ eq
- Flour: 40 kg CO₂ eq
- Sugar: 30 kg CO₂ eq
- Waste: 20 kg CO₂ eq
- Butter: 10 kg CO₂ eq

ILCD 2011 Midpoint+ V1.06, climate change [kg CO₂ eq]
What are BIOPOLYMERS?

- Polymers produced by living organisms (Cellulose, Lignin, Starch, ...)
- Polymers as materials – mainly packaging (PLA, TPS, PHA, Bio-PE, ...)

Biopolymer = Biodegradable (PLA, PHA, TPS)

Biopolymer ≠ Biodegradable (BioPE, BioPET)

Biopolymer = Biobased (PLA, PHA, TPS)

Biopolymer ≠ Biobased (PBAT, PBS, PCL)
LIFE CYCLE – BIOBASED POLYMERS

- **Isolation & Purification**
  - Lactic acid
  - PLA

- **Fermentation**
  - Building blocks (Sugars, Lipids, ...)
  - PHA
  - Starch, Cellulose, Pectin, ...

- **Bio-polymer synthesis/processing**

- **Composting**
  - CO₂, H₂O, Biomass, Humic matter

- **Biowaste treatment**

- **Use phase**
BIOPOLYMERS – IMPACT ON CLIMATE CHANGE

GHG emissions
PBAT, PBS, PBSA, PLA and PHB production

GHG emissions (kg CO2e/kg)

PBAT (OWS, 2014, b.i.c.)
PBSA (OWS, 2014, cons.)
PBAT (OWS, 2014, b.i.c.)
PBSA (OWS, 2014, cons.)
PLA (OWS, 2014)
PLA (Vink, 2007)
PHB (Harding, 2007)
PHB (Akiyama, 2003)
PHB (Kurdikar, 2000)


- Data for modelling – difficult to obtain, often confidential
- Production process not mature enough (PE = +50 y. VS PLA = 15 y.)
- Much smaller production scale (about 20% of all polymeric materials)
- Big impact of feedstock (possible solution: 2nd and 3rd generation feedstocks)
- Big impact of fermentation and extraction (a lot of room for improvement)
PHB SYNPOL – COMPOSTING VS INCINERATION

- Climate change
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- Human toxicity, non-cancer effects
- Human toxicity, cancer effects
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- Ionizing radiation HH
- Ionizing radiation E (interim)
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- Acidification
- Terrestrial eutrophication
- Freshwater eutrophication
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- Land use
- Water resource depletion
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ILCD 2011 Midpoint+ V1.06, relative impact (%)
PHB SYNPOL – AD VS INCINERATION WTE

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ILCD 2011 Midpoint+ V1.06, relative impact (%)

AD vs Incineration WtE
CONCLUSIONS

- LCA – impact on climate change most popular, but not the only assessment parameter
  - 16 impact categories according to ILCD Midpoint method
- Biopolymers – Biobased AND/OR Biodegradable
- Biopolymers production hotspots (general):
  - Electricity, Feedstock
- Biopolymers – production technologies – need for optimization
- PHB Synpol production hotspots:
  - Feedstock (pyrolysis), Emissions (Gas flaring)
- EOL PHB: AD best, Landfilling worst
  - AD > WtE > Composting > Incineration > Landfilling
THANK YOU

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