The potential for plastic packaging to contribute to a circular and resource-efficient economy

Identiplast 2015, Rome, April 29th
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How to get maximum value from limited resources

- Natural resources
- Extraction of raw materials
- Production of technical materials
- Design for optimal functionality
- Distribution
- Use phase, maintenance
- Recycling, energy recovery
- Reuse
- End of life management
- Landfilling, dissipation, increasing entropy

Natural resources → Extraction of raw materials → Production of technical materials → Design for optimal functionality → Distribution → Use phase, maintenance → Recycling, energy recovery → Reuse → End of life management → Landfilling, dissipation, increasing entropy → Extraction of raw materials
Apart from technical feasibility & society benefits, two interlinked aspects of sustainability should be considered to choose optimal waste management options:

- **Environmental benefits**
  Which recovery option provides the highest environmental benefit? Does a simple hierarchy of options exist?  
  → Environmental impact evaluation through **LCA**

- **Economic aspects**
  Do benefits for society (monetised environmental benefits and economic benefits) justify recovery costs?  
  → Cost-benefit analysis (**CBA**)

**Eco-efficient waste management = relevant environmental benefits AND positive cost-benefit-balance**
Packaging Directive:
- Member States shall, where appropriate, encourage energy recovery, where it is preferable to material-recycling for **environmental and cost-benefit reasons**.
- ... fix recycling targets ... based on the practical experience gained, calculation methodology ... and the **findings of scientific research and evaluation techniques** such as **life-cycle assessments and cost-benefit analysis**. This process shall be repeated every five years.
- The Commission shall present a report ... covering ... encouragement of reuse and, in particular, **comparison of the costs and benefits** of reuse and those of recycling

- Further references to LCA and CBA
Main environmental benefits of plastic recycling and recovery:

- Material recycling of plastic waste
- Feedstock recycling of plastic waste
- Energy recovery of plastic waste

Saved fossil resources

Saved GHG emissions
Weighted LCA impacts, two exemplary advanced methods

- GWP + fossil resources cover 82 – 94 % of total footprint

Source: Denkstatt (2014)
GHG net benefit (impact) of various recycling and recovery options for PE

No simple hierarchy can be derived

Industrial energy recovery better than mixed plastic recycling
Methodology of Calculating a Cost-Benefit Balance for Recovery Systems

- Costs of separate collection and sorting
- Net costs of mechanical recycling and energy recovery
+ Savings on costs of residual waste collection
+ Savings on net costs of residual waste treatment and disposal
= Result of Net Cost Analysis of Waste Management \( (A) \)

+ Savings on costs of primary production
  & conventional energy conversion; recovery revenues excluded before \( (B) \)
+ Savings on environmental (= external) costs
  (either “damage costs” or “avoidance costs”) \( (C) \)

= Cost-Benefit Balance \( (A+B+C) \)
Example 1: Cost-benefit balance for recycling of PET bottles

- Benefits of PET recycling outweigh additional costs
- Positive cost-benefit balance

Monetised environmental benefits
Saved costs of primary production
Saved residual waste treatment
Saved residual waste collection
Recycling & energy recovery
Separate collection & sorting

EUR/t of waste collected for recycling

Total = Cost-Benefit Balance
Sum = additional waste management costs

Source: Denkstatt (2007)
Example 2: Cost-benefit balance for recycling of domestic films

Benefits of domestic film recycling do NOT outweigh additional costs

→ negative cost-benefit balance
Estimated cost-benefit balances for recycling of plastic packaging waste streams

Solid Area = realistic recycling rate

Shaded areas = very optimistic recycling rate

Maximum recycling potentials for plastic packaging, given in % of total plastic pack. waste

Somewhere within 36 – 53 %: Limit of sustainable recycling

For remaining plastic packaging waste, recycling would show negative cost-benefit balance (expensive, small benefits)

Source: Denkstatt (2014)
Conclusions from LCA+CBA results

- **No simple general waste hierarchy** can be derived from LCA facts for plastic waste streams. Individual LCA and CBA studies are needed to find eco-efficient solutions.

- The maximum eco-efficient recycling level for plastic packaging is somewhere between 36 % and 53% ➡ not yet entirely utilised

- Recycling beyond this limit
  - will either be low quality recycling (no environmental benefits)
  - or will not be eco-efficient due to very high costs

- Future innovation can help to improve cost-benefit balance

- Optimal European plastic packaging waste recovery (recycling + industrial energy recovery) will save approx. **25 Mill tonnes of CO₂e per year** (compared to 100 % MSWI)
  - equiv. to 138 billion car km or 9 million cars less on the road
A reflection on recycling vs. packaging resource efficiency in total life-cycle

Despite common belief, plastics contribute significantly to increased resource efficiency, even when recycled at a lower rate than other materials.

Source: Denkstatt (2014)
How plastic packaging help to reduce food waste; example cheese packaging

Reduced GHG emissions due to reduction of food losses from 5% to 0.14%

Increased GHG emissions for better packaging

Small relevance of increased transport and less recyclability

Net-benefit of improved packaging solution

Gram CO₂e per 150 g of sliced cheese

Production of wasted cheese
Production of packaging
Transport
Waste treatment cheese
Packaging recovery
Total GHG balance

Cheese sold at counter
Packed cheese at shelf

Source: Denkstatt (2014)
Sustainable design “formula”:

+ optimised material production
  \[ \times \] small material demand per functional unit

+ **high functionality / quality / use-benefits**

+ optimal recovery/recycling-mix *(determined by CBAs!)*

\[ \Rightarrow \] Low eco-footprint, economic & social impact

Priority for functionality, then raw material and recycling aspects
We drive the change to a sustainable society.

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