Combination of MFA and LCA for the evaluation of the plastics packaging waste management system in Austria

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Introduction & Objectives

Plastics (especially from packaging) form an **increasingly large waste stream**, causing challenges for waste management systems. Many policy initiatives have been introduced, mainly focussing on recycling targets:

- EU targets: **currently 22.5%** to recycling, proposed **future targets of 55%** by 2025.

Detailed mapping of material flows is required to:

- Accurately calculate these recycling rates.
- Identify potentials for improvements.
- Assess the environmental performance from a systems perspective.

The aim is to **evaluate the environmental performance of different configurations of the waste management system.** This is exemplified by **comparing the status quo** with a theoretical **scenario reaching the proposed EU targets.**

Methods

Material Flow Analysis (**MFA**) is used to **quantify the flows of plastics packaging** through the Austrian waste management system, on **two levels**:

- **7 product groups**: PET bottles, hollow bodies small, hollow bodies large, films small, films large, EPS large, others.
- **8 polymers**: LDPE, LLDPE, HDPE, PP, PS, EPS, PET, PVC (results not shown here).

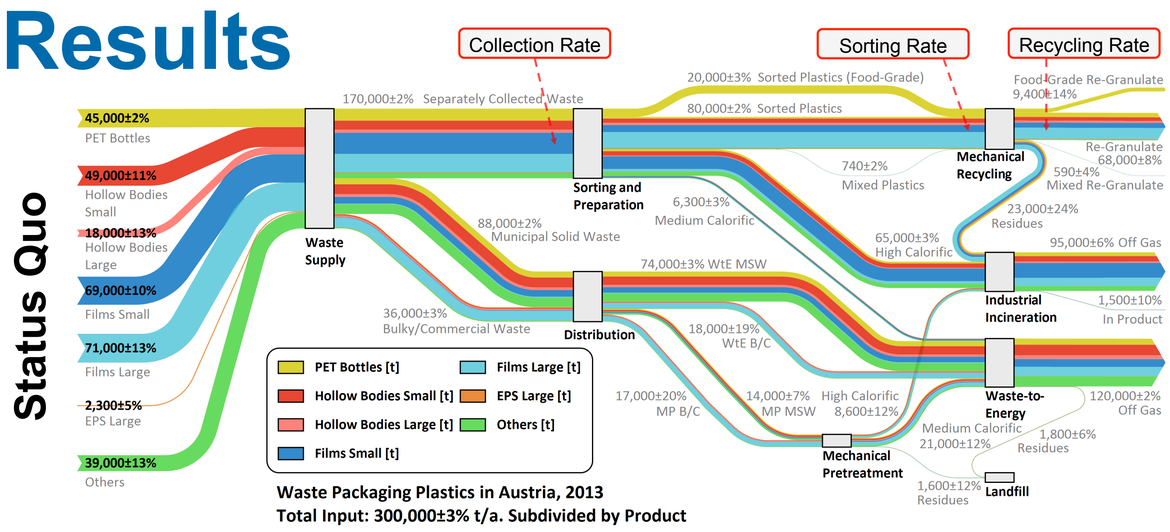
Life Cycle Assessment (**LCA**) was used to **quantify the environmental impacts and benefits** using a systems perspective:

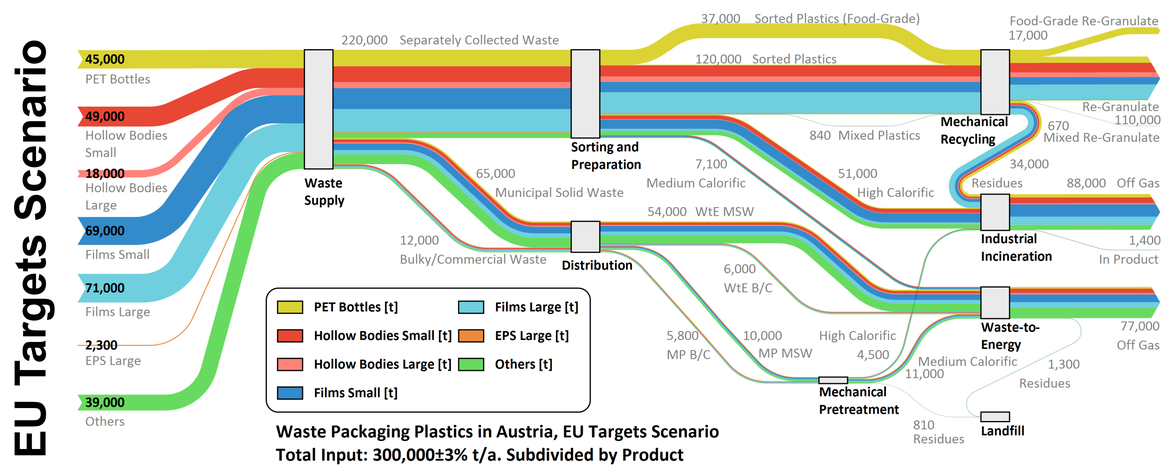
- **Functional unit**: the treatment of the full amount of plastics packaging waste generated in Austria in 2013.

Uncertainties were quantified:

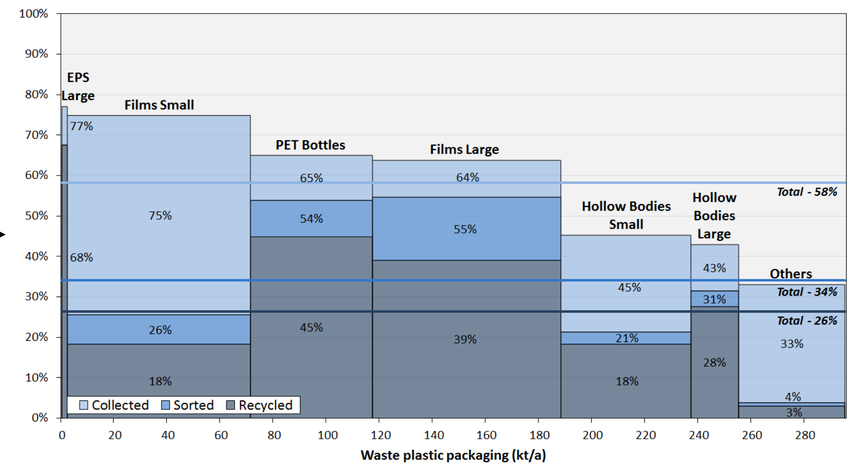
- MFA: using a pedigree approach (see Laner et al. 2016).
- LCA: some uncertain input data were available, otherwise using a pedigree approach (see Weidema et al. 2013).
- Error propagation using an analytical approach (see Bisinella et al. 2016).

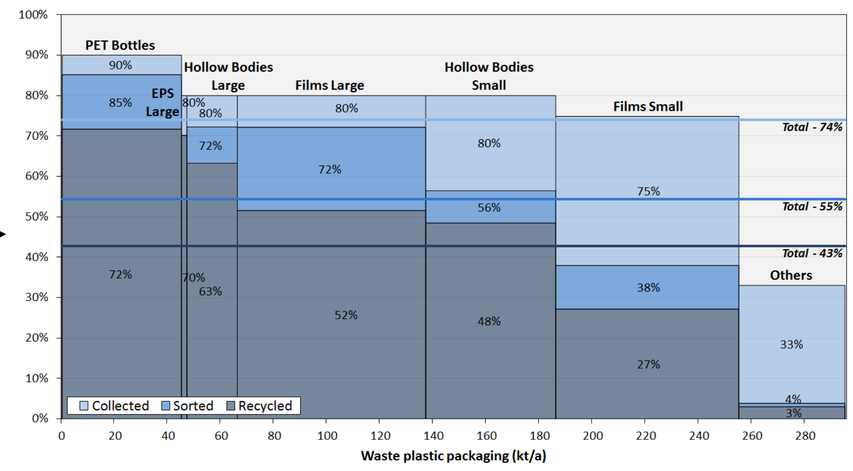
Results





Figures 1 & 2: Material flows of the respective scenarios.





Figures 3 & 4: Collection, sorting and recycling rates of the respective scenarios.

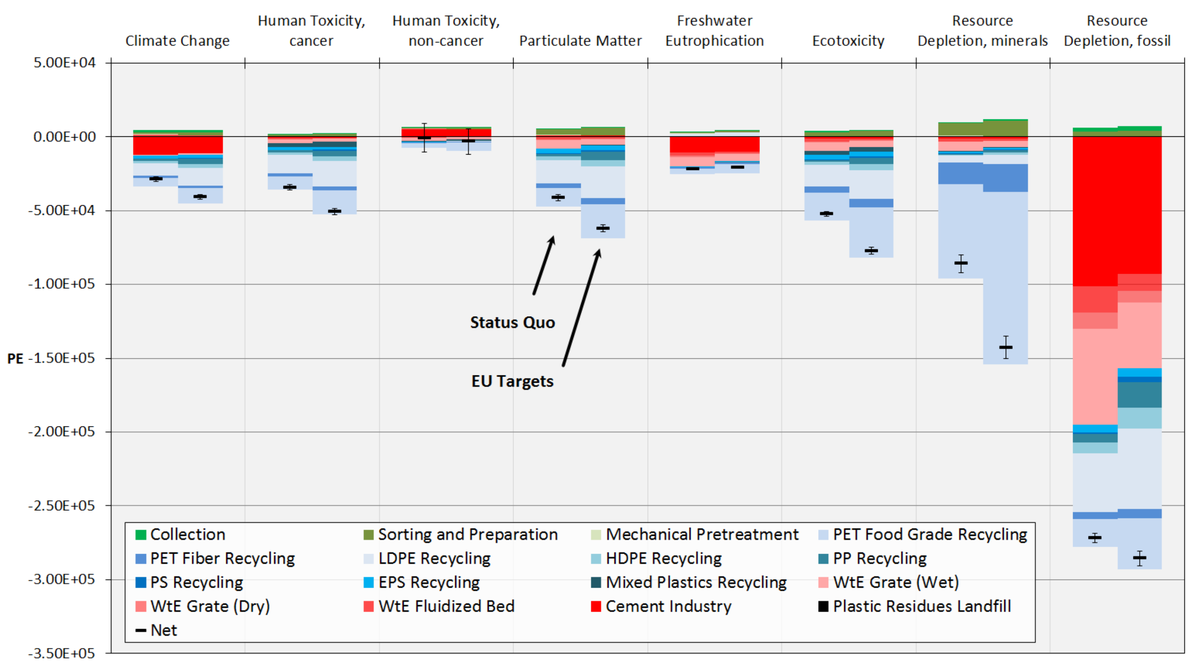


Figure 5: Selected LCA results of the Status Quo and EU Targets scenario.

- The current **EU targets are reached comfortably** (34% > 22.5%, see Figure 3, Sorting Rate).
- **99%** of the waste stream is currently **recycled or thermally recovered**.
- The **highest recycling** rates are achieved for **EPS large, PET bottles and films large**.
- To reach the proposed **future targets, major technological improvements will be needed** to reach the required collection and sorting efficiencies (see Figure 4).

- For the status quo, all impact categories have **net environmental benefits**, although for Human Toxicity (non-cancer) the zero point lies within one standard deviation.
- The benefits are achieved **both by recycling (blues) and incineration (reds)** processes, with varying ratios between the two across the impact categories.
- The **impacts of the collection and sorting processes (greens) are small** compared to the achieved benefits.

- The scenario reaching the future EU targets in general has a **higher environmental benefit** compared to the status quo. However, the improvements are moderate, compared to the substantial increase of collected and recycled material, indicating a **decreasing marginal benefit of further increasing recycling rates**.
- **Further improvements** to the model, such as including the effect of increasing collection on the quality of the waste stream, are expected to **amplify this trend**.

Conclusions & Outlook

- The **thorough understanding of the waste flows** in a waste management system, provided by MFA, is **essential when assessing the environmental impacts**, especially for complex waste streams such as packaging plastics, for which various polymers and product types have to be taken into account.
- The systems perspective allows to identify trade-offs between different treatment processes, and **determine an optimal configuration of the waste flows** by evaluating a large number of possible configurations (see Figure 6).
- By evaluating various configurations of the waste flows environmentally, questions can be answered such as:
  - **Are policy targets actually beneficial environmentally**, compared to the status quo?
  - Is there an **environmentally optimal recycling rate**, taking into account various impact categories and costs?
  - How large is the **improvement potential**, compared to the status quo?

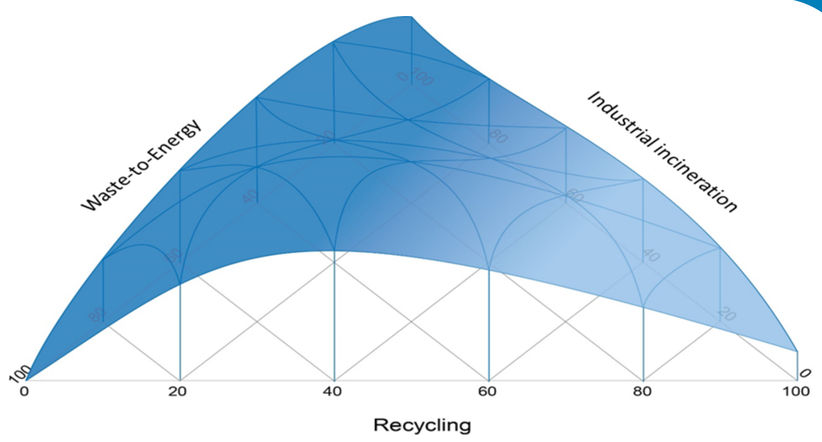


Figure 6: Rates of Recycling, WtE, and Industrial Incineration, and the associated environmental impact (concept).

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References:

- Bisinella et al. 2016. Int J Life Cycle Assess 21 (3) 378-394
- Laner et al. 2016. J Ind Ecol 20 (5) 1050-1063
- Weidema et al. 2013. Ecoinvent Report 1 (v3)