An effort to determine the environmentally optimal recycling rate for plastics packaging

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Introduction & Objectives

Plastics (especially from packaging) form an **increasingly large waste stream**, causing challenges for waste management systems. The proper management of waste plastics is thus vital in achieving increased resource efficiency as well as decreased environmental and human health damage.
Therefore, many policy initiatives have been introduced, mainly focussing on recycling rates:

- EU target for plastic packaging: **currently 22.5%** to recycling, proposed **future target of 55%** by 2030.

However, these quantitative targets are **not based on underlying environmental data**, so trade-offs within the waste management system might not be accounted for.
The question therefore remains, if this new target is environmentally superior to the status quo, and if an environmentally optimal recycling rate exists.

The aim of the study was therefore to assess the plastics packaging waste management system, using Austria as a case study, in three different configurations:

- the **Status Quo** using 2013 as the reference year
- the situation in Austria in **1994**, illustrating a developing waste management system
- a situation which complies with the future recycling target (**2030-Target**)

Methods

A detailed Material Flow Analysis (**MFA**) was carried out to **quantify the flows of plastics packaging** with respect to polymers and product groups (see Van Eygen et al. 2018). This was then combined with **input-dependent inventory data** for each of the treatment processes to perform the Life Cycle Assessment (**LCA**) for 16 impact categories, using EASETECH.

The three scenarios only differ with respect to the routing of the waste flows, and the mass and composition of the input waste was kept constant.

Uncertainties were quantified using:

- a pedigree approach for the MFA (see Laner et al. 2016).
- uncertain input data where available, otherwise a pedigree approach for the LCA (see Weidema et al. 2013).
- error propagation with an analytical approach (see Bisinella et al. 2016).

Results

Results of the three scenarios

- For the status quo, all impact categories except Human Toxicity non-cancer show **higher benefits than impacts**, resulting in net negative impacts.
- In general, the **most benefits are achieved by mechanical recycling**. Industrial incineration and waste-to-energy cause net benefits or net impacts, depending on the impact category.

- For ten from 16 impact categories, the more material is recycled, the higher the overall benefits are.
- For the six remaining impact categories, similar or decreased net benefits are achieved by the 2030-scenario compared to the status quo.

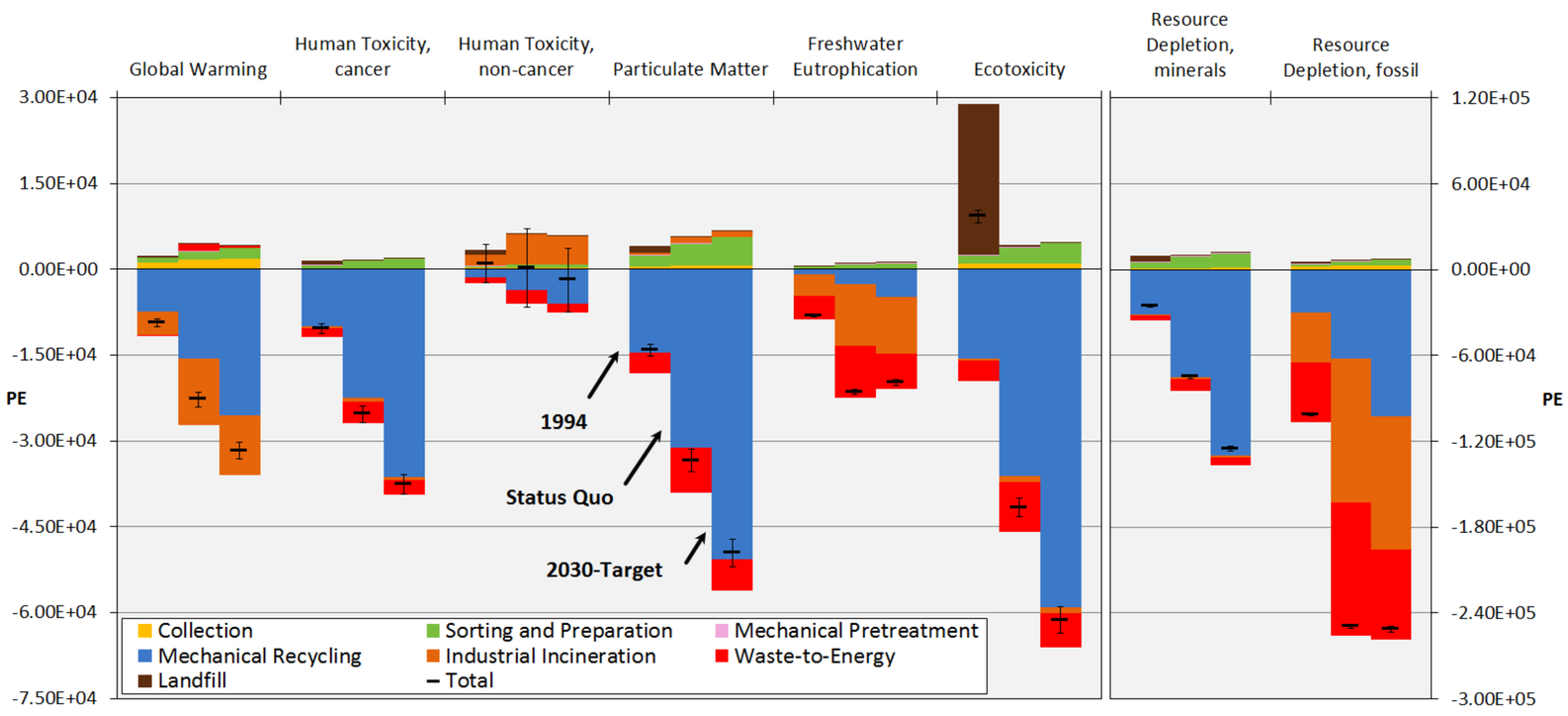

Figure 1: Environmental performance of the waste management system of plastic packaging for eight selected impact categories.

How does this relate to the recycling rate?

- The recycling rate increased by:
  - 17 percentage points between 1994 and the status quo.
  - 22 percentage points between the status quo and the 2030-scenario.

- **Three types of relationships** are observed between the normalized results of the 16 impact categories and the recycling rate:
  1. **Increasing marginal benefit**: <u>one</u> impact category (Human Toxicity non-cancer)
  2. **Decreasing marginal benefit or even absolute decrease**: <u>eight</u> impact categories (Ozone Depletion, Ecotoxicity, Resource Depletion fossil, Marine Eutrophication, Ionizing Radiation, Land Use, Resource Depletion water)
  3. **Approximately linear or slightly decreasing marginal benefit**: <u>seven</u> impact categories (Resource Depletion minerals, Global Warming, Human Toxicity cancer, Particulate Matter, Photochemical Ozone Formation, Terrestrial Acidification, Terrestrial Eutrophication)

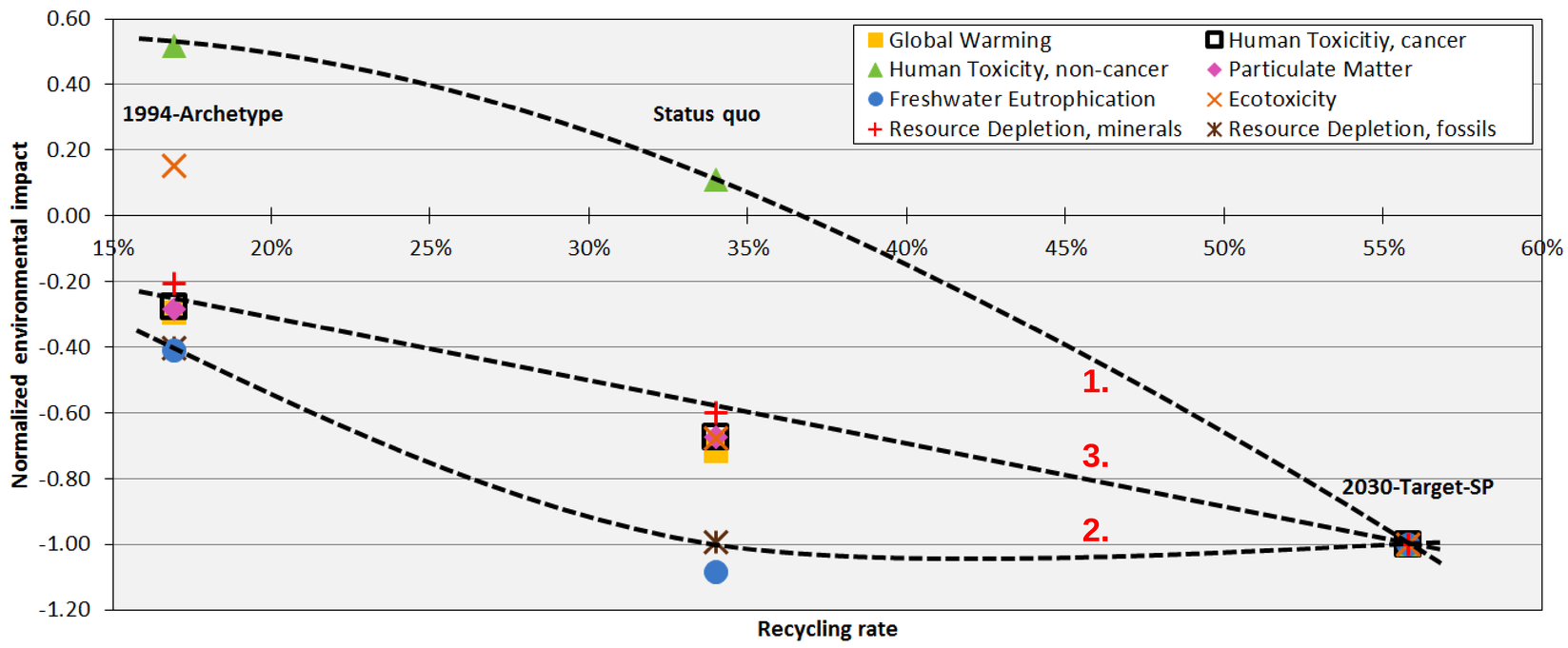

Figure 2: Normalized results (2030-Target-SP = -1) in relation to the recycling rate for eight selected impact categories.

Conclusions

- The alternative waste management scenarios indicate that in general increasing recycling rates lead to increased benefits.
  However, for many impact categories the marginal benefit decreases with increasing recycling rates.
  → **The environmentally optimal recycling rate is below 100%.**

- Furthermore, the various impact categories show different trends for increasing recycling rates.
  → **Determining a potential optimal recycling rate strongly depends on the impact category.**

- In this study, no non-linear effects of e.g. increasing separate collection on transport distances and sorting efficiency are included, which would likely decrease the benefits of increasing recycling.

- It is thus important to **carefully consider the effects of increasing recycling targets on the overall environmental performance**.

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
- Van Eygen et al. 2018
  Waste Manage 27 55-64
- Weidema et al. 2013.
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