Product Sustainability

The impact of plastic packaging on life cycle energy consumption and greenhouse gas emissions in Europe

Executive Summary

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1 Introduction

In order to produce plastic packaging, energy resources are consumed. Currently such energy resources are almost entirely obtained from non-renewable sources and by using them, greenhouse gas (GHG) emissions are produced. Nevertheless, even more energy would be consumed and more GHG emissions emitted, if plastic packaging were to be substituted by alternative materials. This is one of the main findings of a detailed study presented below.

In addition, many plastic packaging products enable energy savings during their use-phase, even without being compared to other materials. Examples are packaging applications that reduce food losses or help to avoid damage to durable goods (which is valid to some extent for other packaging materials also).

This report on packaging was extracted from the study "The impact of plastics on life cycle energy consumption and greenhouse gas emissions in Europe" produced by Denkstatt and published in July 2010. The study has been critically reviewed by Adisa Azapagic, Professor of Sustainable Chemical Engineering at the School of Chemical Engineering and Analytical Science, University of Manchester, United Kingdom and Roland Hischier, member of the Technology & Society Laboratory at EMPA, the Swiss Federal Laboratories for Materials Testing & Research in Sankt Gallen, Switzerland.

2 Goal & Scope of the Study

The goals of this analysis were to

- calculate the life-cycle energy consumption and GHG emissions, if plastic packaging applications in Europe (EU27+2) were to be (theoretically) substituted by a mix of alternative packaging materials as available on the market
- explain why even the use of current fossil fuel based plastic packaging does indeed make a significant positive contribution to goals of energy efficiency & climate protection
- formally confirm that the use of plastic packaging can in many cases actually help save resources across the whole life-cycle
- investigate some other important issues related to energy consumption and GHG emissions, like the use of biodegradable plastics or the effects of different ways to recycle and recover plastic waste.

It was NOT the intention to claim an overall material superiority. Every packaging material has special benefits in certain application sectors. Often the most efficient solution may be a combination of different materials.

3 Calculation model and data sources

To develop a model for a theoretical substitution of plastic packaging, the total packaging market was split into by seven sectors (market shares within total plastic packaging in brackets): "small packaging" (7.7 %), "PET beverage bottles" (12 %), "other bottles" (6.1 %), "other rigid packaging" (31.8 %), "shrink & stretch films" (10.8 %), "shopping bags" (3.3 %), and "other flexible packaging" (26.1 %).

Within these 7 case studies 57 products were examined including the following

- polymers: LDPE, LLDPE, HDPE, PP, PVC, PS, EPS and PET
- alternative packaging materials: tin plate & steel packaging, aluminium, glass, corrugated board, cardboard, paper & fibre cast, paper based composites and wood.

Details of the substitution model were developed by the German market research institute GVM, based on 32 packaging categories, more than 70 different materials, and a database containing 26,000 data sets of packaging materials, sizes, volumes, and masses.

Data for the production phase of plastic packaging are mostly taken from the "Ecoprofiles" as published by PlasticsEurope. Production data for alternative materials are taken from the Ecoinvent database or comparable sources.

Exemplary use phase effects considered in this analysis are:

- PET bottles need less volume on trucks than glass bottles ⇨ less trucks for same amount of drinks
- Plastic food packaging contributes to shelf life extensions of fresh food ⇨ prevented food losses

Assumptions for recycling, energy recovery and disposal of packaging materials are in line with the average situation in the EU27+2 in 2007.

4 Main results

If plastic packaging would be substituted by other materials,

- the respective packaging mass would on average increase by a factor 3.6
- life-cycle energy demand would increase by a factor 2.2 or by 1,240 million GJ per year, which is equivalent 27 Mt of crude oil in106 VLCC tankers or comparable to 20 million heated homes
- GHG emissions would increase by a factor 2.7 or by 61 million tonnes of CO_2-equivalents per year, comparable to 21 million cars on the road or equivalent to the CO_2-emissions of Denmark.

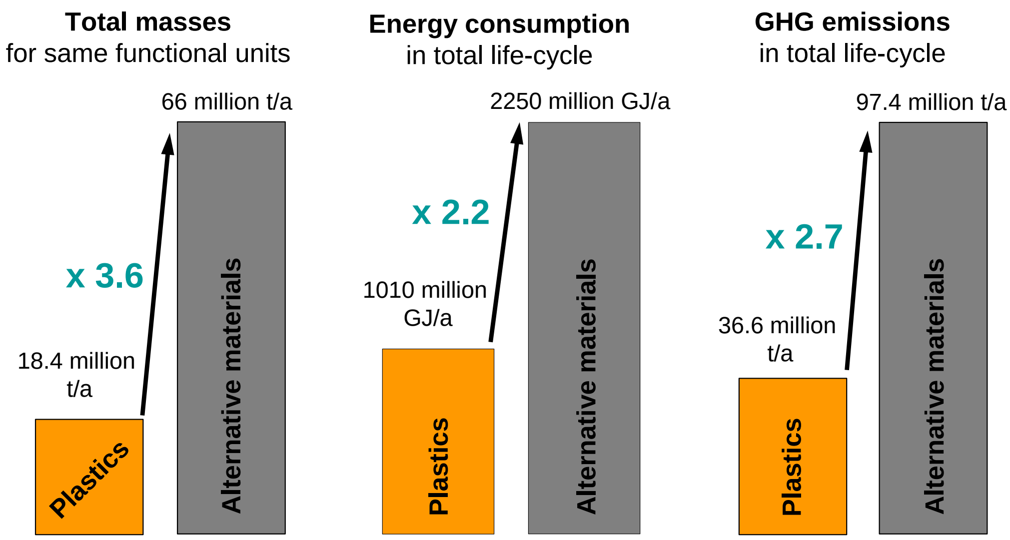

Figure 1: Effect of substitution of selected plastic packaging on masses, energy demand & GHG emissions

The main reasons for this result are:

- Plastic packaging usually provide the same function with significantly less material mass per functional unit. In most cases this leads to less production energy and GHG emissions per functional unit than for the mix of alternative materials.
- Benefits in the use-phase (prevented food losses, less energy for transportation) are also a relevant contribution to the result (see figures below).
- The net-benefits of recycling and recovery of plastic packaging are often higher than for alternative materials, because most of the recycling benefits of alternative materials are already included in the datasets for production, where relevant shares of recycled raw material are included.

All seven investigated plastic packaging sectors show advantages compared to the mix of alternative materials. Among these plastic packaging sectors "beverage bottles", "shrink & stretch films" and "other flexible packaging" show the highest contributions to the total benefit (see Figure 2).

"Other rigid packaging" and "small packaging" need more energy to be produced than alternative materials, but this is more than compensated by benefits in use-phase and in waste management.

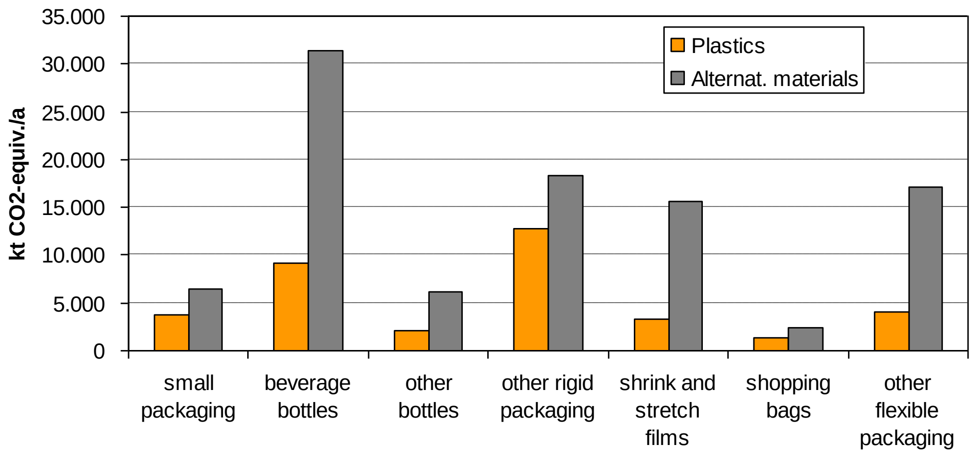

Figure 2: Effect of substitution of plastic packaging on life-cycle GHG emissions

GHG benefit due to prevented food losses as a result of using plastic packaging to protect fresh food is at least equivalent to 37 % of production emissions of all investigated plastic packaging (see Figure 6).

The character of the main findings (more energy demand & more GHG emissions when plastic packaging was substituted by other materials) is not changed by recycling scenarios. Current plastic recycling levels reduce life-cycle energy demand by 24 % and GHG emissions by 27 %. Even with no plastic recycling, plastic packaging would cause less GHG emissions than alternative materials (see Figure 3).

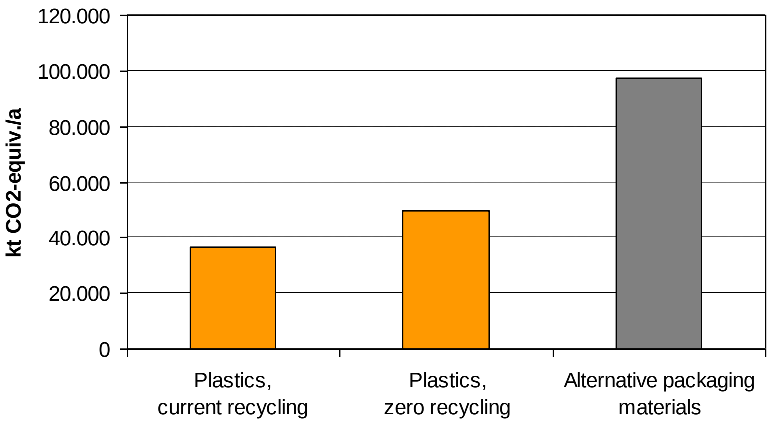

Figure 3: Influence of plastic recycling on life-cycle GHG emissions

5 Further important findings

Beside the results presented above, also a "carbon balance" was established, defined as the "amount of greenhouse gases prevented" (as a result of the use- and recovery-benefits of plastic packaging) divided by the "amount of greenhouse gases emitted during the production of plastic packaging" (both figures expressed in CO_2-equivalents).

Such a carbon balance has been established for the total market of plastic packaging consumed in the EU 27+2 in the year 2007. It should be noted that the list of examples for use benefits in the carbon balance is not complete, but rather shows relevant applications where the benefits have so far been quantified (see Figure 6).

In 2007 the estimated use benefits of plastic packaging were 5 times higher than the emissions from the production and recovery phases.

Generally the relevance of the environmental impacts of packaging seem to be overestimated by far: Only 1.7 % of the total consumer carbon footprint is related to all domestic and commercial packaging materials used in the EU27+2 (see Figure 4). The use of plastic packaging is related to only 0.6 % of the average carbon footprint of the European consumer (the use benefits, which are at least 5 times higher than the production burden, are not included here).

Further important findings are:

- The GHG benefit of prevented food losses is (on average) at least 5 times higher than the burden of packaging production, if only 10 % less of the packed food is wasted.
- Recycling and recovery of plastic packaging helps saving energy resources; recovery processes with high efficiency also enable reductions in GHG emissions.
- The annual plastic shopping bag consumption is equivalent to (only) 0.14 – 0.3 perMILL of the average consumer carbon footprint or comparable to 13 – 26 km of driving.
- Biodegradable plastic packaging is not per definition better than conventional plastic packaging. Such a comparison strongly depends on the mass ratio of the products, the specific materials used and the waste management conditions given in each country.

6 Conclusions

Plastics applied in the packaging sector today, are mostly used as a very energy efficient material. Plastics enable resource efficient packaging solutions, which result in significant savings of energy and GHG emissions. This is due to the fact that plastic packaging facilitates significantly reduced material consumption which results in less energy consumption for the same functional unit.

In addition many plastic packaging products save significant amounts of energy and GHG emissions during the use phase. These benefits are especially significant, when plastic packaging can be used to increase the shelf-life of food resulting in reduction of food wastage.

Vice versa the substitution of plastic packaging by other materials would in most cases increase energy consumption and GHG emissions.

Finally a "carbon balance" for plastic packaging shows that the estimated use benefits are at least 5 times higher than the emissions from production & recovery.

7 Annex to summary: Selected additional figures

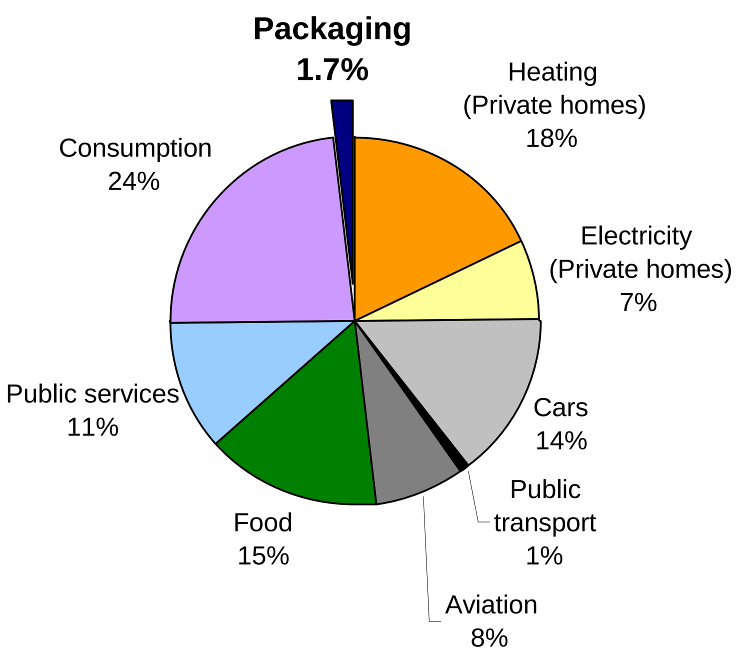

Figure 4: All domestic and commercial packaging materials used in Europe are only related to 1.7 % of the total average consumer carbon footprint. Plastic packaging (use-benefits excluded) are related to 0.6 % of the average consumer carbon footprint.

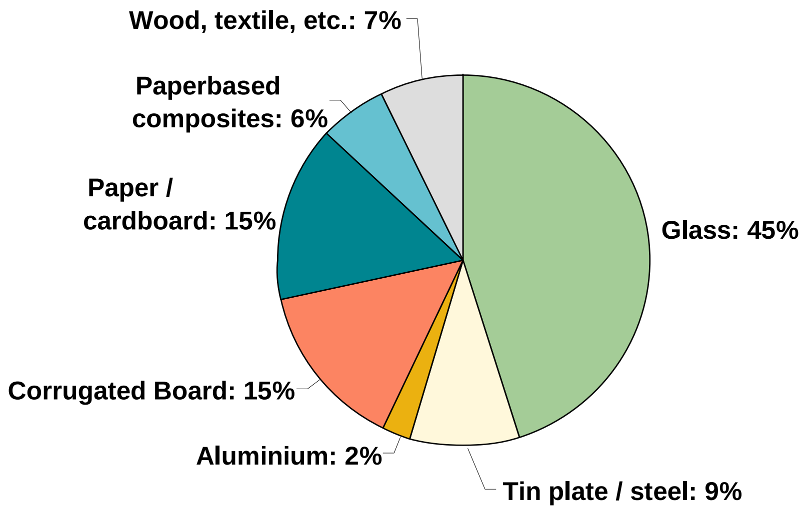

Figure 5: Composition of packaging materials needed for a theoretical substitution of plastic packaging

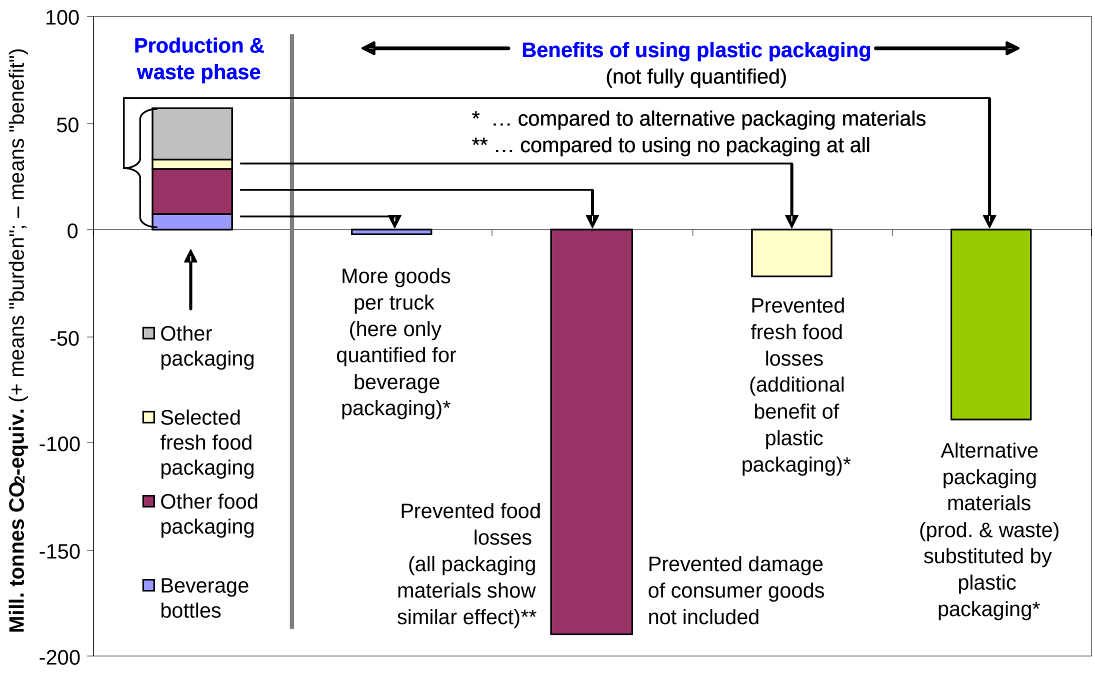

Figure 6: GHG emissions caused by production & waste management of plastic packaging, compared with GHG benefits resulting from the use of plastic packaging