Plastics and Climate in Perspective

Most Plastics are a Net Reducer of GHG Emissions — Research Summary prepared by denkstatt Vienna, September 2020

Do plastic products increase GHG emissions, or do they help to decrease GHG emissions? This question is discussed controversially. In 2019, the Center for International Environmental Law (CIEL) has released a report called "Plastic & Climate: The Hidden Costs of a Plastic Planet"[1], which looks at plastics production and greenhouse gas emissions and claims that plastic proliferation threatens the climate on a global scale. Reducing greenhouse gas emissions is indeed a critical global challenge, and rigorous emissions studies are an important tool for understanding the carbon impacts of products. However, CIEL only looked at one side of the equation, GHG emissions from plastic use. CIEL did not look at the GHG emissions of alternative products that would be used instead. The document in hand elaborates this wider perspective of comparing impacts and benefits of using plastic products, and concludes: **The emissions saved within total life-cycle are often higher than the impacts of plastic production and recovery.** In 2010, these benefits were estimated to be 5 – 9 times higher than the impacts of the total market of plastic products in Europe.[3]

Full life cycle approach, comparing alternatives

Plastic products cause environmental impacts and benefits throughout their life cycle. During the production phase usually impacts arise. Within the use phase products can sometimes cause further environmental impacts. But often the usage of plastic products influences systems in a way that energy consumption is reduced (e.g. by thermal insulation) and resource efficiency is increased (e.g. food packaging reducing food waste), resulting in reduced environmental impacts (= benefits). At the end of life, various options can lead to a net-impact or a net-benefit due to impacts and credits from recycling, energy recovery and disposal.

The key question is: Are the benefits of using a product higher than its impacts, or vice versa? Compared to alternatives, or compared to not using any material, many plastic products enable benefits which are higher than the impacts of production and waste recovery, which will be explained in this document. Generally, the benefits of using plastic products, compared to alternatives, can arise from the production phase (lower impacts due to less material per functional unit), the use phase (better functionality than alternatives), and the end-of-life phase (e.g. from higher recycling credits).

Life cycle assessment (LCA) and carbon footprint calculations compare products **based on the same functional unit**. LCA and carbon footprint results can be categorized into 3 different groups, with different consequences for plastics sustainability strategies:

1. **Benefits greater than impacts:** For plastic products generating more benefits than impacts, increased use is clearly beneficial and sustainable due to the reduced environmental impacts.
2. **No clear ranking:** Plastic products showing no clear ranking today, when compared to alternatives, should be optimised.
3. **Impacts greater than benefits:** If optimisation of these plastic products does not result in a sustainable relation of impacts and benefits, alternative solutions should be preferred.

This document is not limited to effects on climate change, but a focus is given to greenhouse gas (GHG) emissions as they are proved to be the most relevant environmental impact of plastics (see Figure 1) and they are the main topic in [CIEL, 2019].

Topic 1: Would a theoretical substitution of plastics by alternatives increase or decrease GHG emissions?

Four peer reviewed studies have investigated the effects of a theoretical substitution of plastic products by alternative materials. In 2016, Trucost compared the environmental effects of plastic consumer products and packaging, used globally, to those of non-plastic alternatives.[2] The assessment considered a wide range of environmental impacts like climate change, air pollution, land and water pollution, water depletion, waste management costs and disamenity, and ocean damage. These impacts were finally transformed into monetary values, representing the environmental costs of plastics and alternatives.

The results showed that the environmental cost of using alternative materials is approximately four times that of using plastic in a business as usual scenario (see Figure 1). In most cases the environmental cost per kilogram of alternative material is less than that of plastic. However, on average over four times more alternative material is needed (by weight) to perform the same functions. Figure 1 also shows that GHG emissions are the most relevant environmental impacts caused by plastics (51 % of total environmental cost), while ocean damage contributes with only 3.6 %.

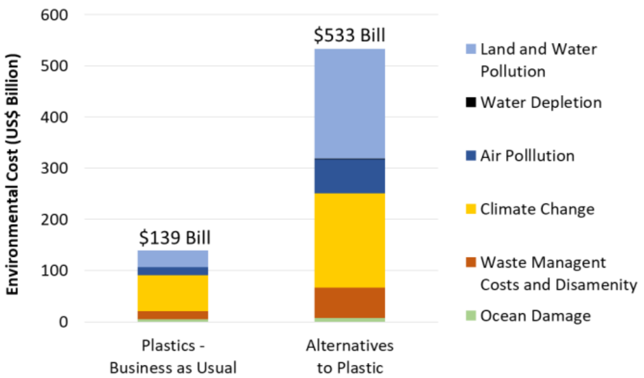

Figure 1: Environmental costs of plastics versus alternatives in the consumer goods sector [Trucost 2016]

In 2010, denkstatt elaborated a similar study, investigating the effects of a theoretical substitution of plastic products in all application sectors in Europe.[3] Results showed that 3.7 times more alternative material is needed (by weight) to perform the same functions. Substituting plastics would increase energy consumption in total life-cycle by 57 %, and GHG emissions by 61 %.

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[1] CIEL (2019): Plastic & Climate - The Hidden Costs of a Plastic Planet. Center for International Environmental Law (CIEL). www.ciel.org/plasticandclimate

[2] Trucost (2016): Plastics and Sustainability: A Valuation of Environmental Benefits, Costs and Opportunities for Continuous Improvement. https://www.trucost.com/publication/plastics-and-sustainability/

[3] denkstatt (2010): The impact of plastics on life cycle energy consumption and greenhouse gas emissions in Europe. https://www.plasticseurope.org/application/files/9015/1310/4686/september-2010-the-impact-of-plastic.pdf

In 2011 denkstatt repeated the same study with a focus on plastic packaging used in Europe.[4] It turned out that the alternatives for plastic packaging are on average 3.6 times heavier. In addition they would consume 2.2 times the energy and cause 2.7 times the GHG emissions of plastic packaging in total life-cycle.

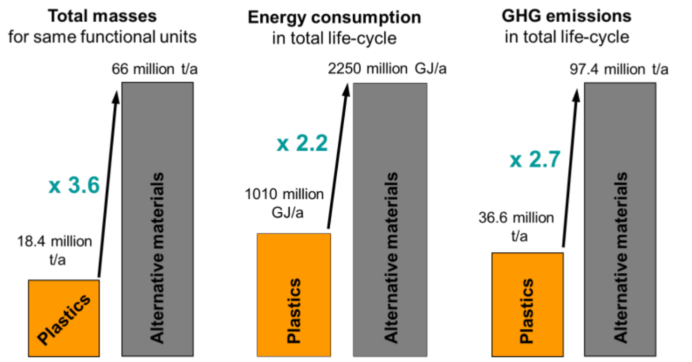

Figure 2: Effects of a theoretical substitution of plastic packaging used in Europe by alternatives [denkstatt 2011]

In 2018 Franklin Associates performed this theoretical substitution analysis for plastic packaging and alternatives for the United States and Canada.[5] Due to the high influence of methane emissions from biodegradable packaging materials disposed in landfills, scenarios with different shares of decomposition were elaborated. Based on only 50 % decomposition, substitutes cause 1.8 times the GHG emissions than plastic packaging used on North America.

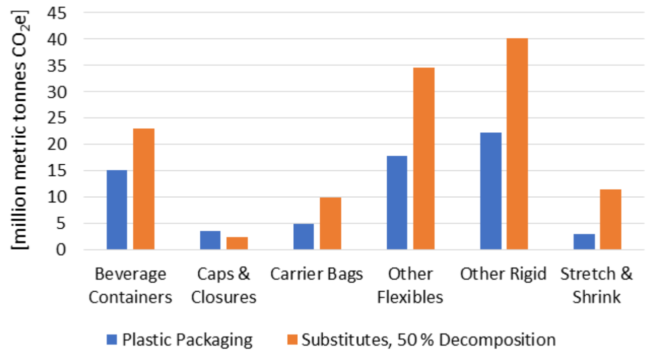

Figure 3: GWP results by Category for US & Canadian Plastic Packaging and Substitutes [Franklin 2018]

In summary, the results of these four studies are similar: Replacing all plastic (packaging) products would increase energy consumption and GHG emissions considerably. **Compared to alternative materials, current plastic packaging used in Europe and North America generate 116 Mill tonnes less CO_2e per year, which is equivalent to the impact of 25 coal fired 500 MW power plants.**

Topic 2: Details on plastic packaging; benefits of avoided food losses

Also on the level of specific packaging products many studies show that solutions with plastics can cause less GHG emissions in their total life cycle than alternative materials. According to [Fehringer, 2019][6] glass one-way bottles cause 3 times the GHG emissions than PET one-way bottles, and refillable glass bottles 40 % higher GHG emissions than refillable PET bottles. An Austria research project on food packaging[7] showed that coffee capsules made from PP with an EVOH barrier cause 40 % less GHG emissions than aluminium capsules, and a PP tray plus PET flowpack for mini cucumbers cause 55 % less GHG emissions than a carton tray plus cellulose flowpack.

Packaging solutions with high or 100 % recycled PET content are often preferable compared to alternatives. Pulp egg packs (100 % recycled paper) generate 19 % more CO_2e in Austria than egg packs made from 100 % recycled PET bottles.[7] This difference is even higher in countries where residual waste is still landfilled. Water bottles made from 100 % recycled PET cause 20 % less GHG emissions than bottles from virgin PET.[6]

When comparing specific products at a wider range of environmental impacts, the results can of course be more differentiated than the conclusions for the total packaging sector, as described above. According to [IVL, 2020a][8] the carbon footprint of single use plastics (SUP) drinking bottles is about half of those of alternatives, while for other environmental impact categories no clear ranking can be derived. [Fehringer, 2019] found the same for milk packaging, when comparing PET and HDPE bottles with beverage cartons (enabled by a plastic coating) at a broader range of environmental impacts. SUP food containers perform significantly better than single-use non-plastic options when GHG emissions are compared, while in other impact categories it was vice versa [IVL, 2020a].

Packaging solutions which contribute to reducing food waste usually generate respective environmental benefits which are much greater than the impacts of the packaging itself. A study of denkstatt in 2015, updated in 2017[9], has quantitatively proven this for five plastic packaging examples (for roast beef, sliced cheese, yeast plait, garden cress, and cucumber), based on data on reduced food waste from Austrian retailers.

Increased protection or improved storage conditions of the packed food due to optimised packaging results in an extended shelf life at retailers and better durability at consumers. Both effects can reduce food waste. The research project “STOP waste – SAVE food” investigated this topic from 2016 – 2020. Results were published in a guidance document in 2020.[7] Further quantitative examples for food waste reductions due to (optimised) packaging could be presented:

For sliced ham two options of packaging with modified atmosphere (MAP) were compared with buying ham from the fresh food counter. The shorter shelf life of ham from the fresh food counter significantly increases the risk of waste at the retailer and consumer (see Figure 4). The carbon footprint results show that the benefit of reduced ham waste is 2.8 times higher than the average additional impact of the MAP packs compared to packaging used at the fresh food counter.

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[5] Franklin (2018): Life cycle impacts of plastic packaging compared to substitutes in the United States and Canada. https://plastics.americanchemistry.com/Reports-and-Publications/LCA-of-Plastic-Packaging-Compared-to-Substitutes.pdf
[6] Fehringer (2019): LCA of packaging made of PET and alternative materials.
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[8] IVL (2020a): Single-use plastic bottles and their alternatives. Prepared by the Swedish Environmental Research Institute (IVL).
[9] denkstatt (2015 / update 2017): How Packaging Contributes to Food Waste Prevention. https://denkstatt.eu/download/1954/

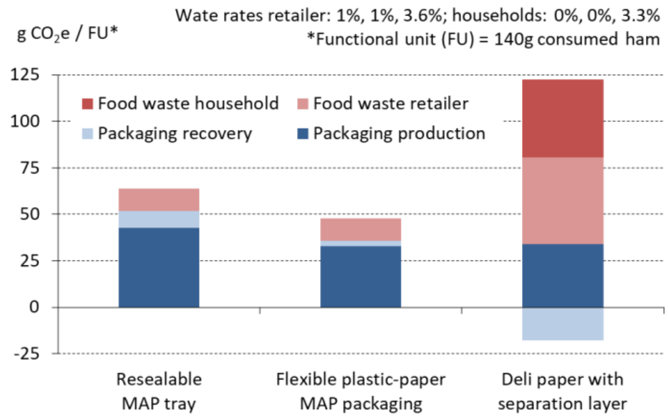

Figure 4: GWP results for three options to purchase slices ham, including the influence of packaging on food waste [SWSF 2020]. Food waste rates are based on data from retailers and on a consumer simulation case study.

Vacuum packaging for beef cuts causes 8 % more carbon footprint than the alternative MAP packaging, but the benefit of reduced food waste is 42 times higher than the additional impact of the improved packaging version. Where consumption rates are low, portion packs can help to reduce food waste. The respective benefits due to less food waste (case studies cream cheese and camembert) are 2 – 5 times higher than the additional impact of the portion packaging. Further examples for snack tomatoes and mini cucumbers show the advantages of plastic packaging as well [SWSF 2020].

Reduction of food waste at retailers due to improved packaging and increased shelf life has to be examined for each individual case using the evidence of concrete data, before and after a changeover. However, examples examined in detail so far show a first trend: doubling the shelf life can reduce the waste rate in the retail sector by about 40% [SWSF 2020].

Based on the cased studies investigated so far, denkstatt estimates that approx. 2/3 of fresh food packaging made of plastics helps to reduce food waste. If this is the case, the environmental benefit of avoided waste is usually 5 to 10 times higher than the environmental cost of the packaging. In Europe and North America approx. 11 Mill tonnes of CO2e are "invested" in fresh food packaging. **The respective benefit of reduced food losses is estimated at 45 – 60 Mill tonnes of CO2e. The average net benefit of 42 Mill tonnes CO2e is equivalent to the carbon footprint of the nutrition for 14 Mill people in Europe and North America.**

Topic 3: Details on non-packaging sectors and products

Also many non-packaging plastic products generate less GHG emissions compared to alternatives. Automotive PP fender modules cause 55 % less GHG emissions than steel fender modules; PP washing machine tubs 80 % less than steel tubs; and EPS insulation 35 % less than stone wool.[10]

TEPPFA commissioned a series of LCAs comparing plastic pipes with alternatives.[11] Pipes for water supply as well as hot&cold pipes cause lower environmental impacts (water supply: GWP –77 % for PE vs. ductile iron resp. –48 % to –86 % for other impact categories; hot&cold pipes: GWP –72 % for PEX vs copper resp. –48 % to –96 % for other impact categories). Sewer pipes don't show a clear ranking (GWP: –22 % for PVC vs concrete, resp. -15 % to +63 % for other impact categories).

According to IVL[12] single use plastic bags (SUPBs) perform poorly for littering, but outperform in terms of impacts on climate change, water and land use, acidification and eutrophication. Paper bags can outperform SUPBs on climate, but only under specific, not widespread conditions. Biodegradable shopping bags tend to perform worst in terms of climate impacts, acidification, eutrophication and toxicity. A reusable cotton bag needs to be used 50 – 150 times in order to outperform a SUPB. This is only 10 – 20 times for a reusable PP bag and 5 – 10 times for a reusable PE bag.

Stenning[13] found out that for one use of an item, most single-use non-plastics (e.g. carrier bags, sanitary towels, cigarette buds, cutlery, stirrers) perform better for climate, to varying degrees based on type of item. Plastic drinks bottles and straws cause less GHG emissions than alternatives. Single-use non-plastics products tend to be worse for all other impact categories. Multi-use products perform best overall where they can be a relevant substitute, apart from small items due to burdens at the washing stage (straws, cutlery). Drinking cups & lids are the only items where SUPs perform worse in all 7 considered impact categories, but these were compared with multi use non-plastics only.

Summary topics 1-3: Benefits are often greater than impacts

As explained above, the majority of plastic products help to reduce GHG emissions, compared to alternative solutions. **The emissions saved within total life-cycle are often higher than the impacts of plastic production and recovery.** In 2010, these GHG benefits were estimated to be 5 – 9 times higher than the GHG impacts of all plastic products used in Europe.[3]

Based on global data for 2017, denkstatt calculated that about 5.4 % of fossil resources are used for plastics (production of polymers, conversion, end-of-life treatment).[14] These 5.4 % help to reduce the environmental impacts of the remaining 94.6 % of fossil energy, which are used in other sectors.

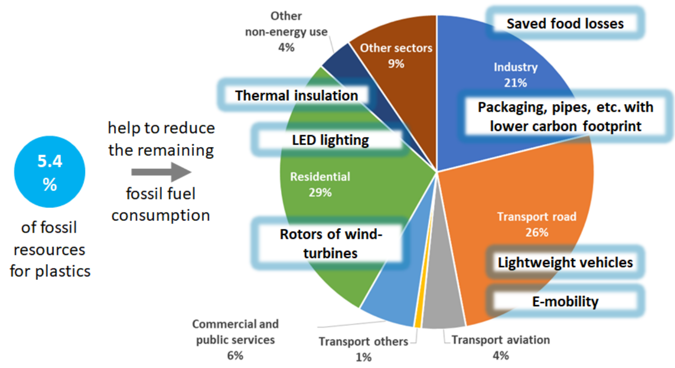

Figure 5: Fossil resources used for plastics help to reduce the environmental impacts of the remaining 94.6 % of fossil energy, e.g. by reducing heating energy, or via energy saving technologies.

[10] denkstatt (2013): Beyond Carbon Footprint – The contribution of selected plastic products to various resource and emission savings. Case study summaries are available via PlasticsEurope.

[11] TEPPFA (2020): Life cycle assessment of plastic pipes and alternatives. Prepared by the Flemish Institute for Technological Research (VITO). https://www.teppfa.eu/sustainability/. TEPPFA - The European Plastic Pipes and Fittings Association

[12] IVL (2020b): Single-use plastic bags and their alternatives - Recommendations from LCA. Prepared by the Swedish Environmental Research Institute (IVL).

[13] Stenning et al (2019): Life Cycle Inventories of Single-use plastics and their alternatives. Prepared by Cambridge Econometrics and denkstatt.

[14] denkstatt (2020): Own calculation based on data from Eustat and PlasticsEurope for 2017, and denkstatt (2017)[24].

Topic 4: Greenhouse gas reductions by improvement over time, in all stages of the plastics value chain

Plastic products were continuously improved in the past in all life-cycle stages and are still being improved to enhance the relation of benefits and impacts:

Improvement of production via resource efficiency, recyclates, and bio-based resources: Plastics producers continuously improve energy and resource efficiency of their production processes. For example, PP production now reaches 99.7 % material yield against 84 % in 1968. PVC production in Europe has also reduced its energy demand by 9.5 % and its GHG emission by 14.4 % from 2008 to 2016.

More than 4 million tonnes of recyclates from post-consumer waste were used in new products in 2018 in the EU28+2.[15] The consumption of recycled PET should increase by 2 million tonnes by 2025[16] while the volume of recycled post-consumer polyolefin content used in European products should rise to 3 million tonnes a year by 2025.[17] Recycled content usually reduces GHG emissions (see page 2). GHG emissions of detergent bottles are reduced by 48 % when using 100 % R-PET instead of fossil-based PET.[18]

Bio-based plastics (e.g. PET or PE from natural feedstock) can reduce GHG emissions of polymer production, if there are no impacts from land use change. However, other environmental impacts can be higher for bio-based plastics than for fossil-based plastics.[19, 20]

Conversion and product design: Improved design resulting in "downgauging" as well as increasing functionality and recyclability are key factors for a steady improvement. For average plastic packaging the material demand decreased by 35 % between 1991 and 2013, reducing GHG emissions per functional unit by 32 %.[18] To increase recyclability, more and more mono-material solutions are being developed.

Use phase: One of the most relevant parameters of sustainable products and for generating environmental benefits is an optimal functional performance of the product in the use phase. Several studies have quantitatively proved this aspect especially for food packaging – see pages 2 and 3. Food packaging protects food with a carbon footprint which is on average 30 times higher than the carbon footprint of packaging.[7] The functionality of plastic packaging is still being improved (e.g. via vacuum packaging, barrier layers, product specific hole sizes in films to optimise humidity and gas mixture, etc.).

Replacing one-way systems by reuse systems is another way to reduce GHG emissions. PET refillable bottles are the best option in many LCA studies on beverage packaging options.[6,21] GHG emissions are also reduced where plastic re-use crates substitute one-way carton boxes.[22]

Waste management: PlasticsEurope and ACC will aim at achieving the goal of 100% re-use, recycling and or recovery of all plastics packaging in the EU and the United States by 2040 (60 % by 2030 in the EU).[23] VinylPlus.eu targets to recycle 800,000 tonnes/year of PVC by 2020. While recycling & energy recovery of plastic waste has increased, landfilling has decreased throughout the last years. From 2006 to 2018, the total quantities of plastic waste sent to recycling facilities increased twofold, while landfilled quantities fell by 44%.[15] High quality recycling performs best in reducing GHG emissions, while low quality recycling is less beneficial than industrial energy recovery, where fossil resources (including their production) are substituted with a very high efficiency.[24]

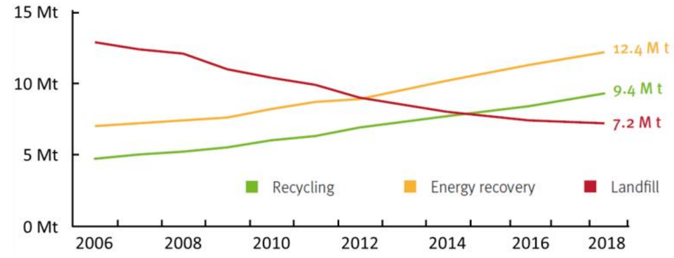

Figure 6: Waste treatment of post-consumer plastic waste in EU28+2

Summary: Decoupling by improvement over time

Reducing GHG emissions require a combination of the decarbonisation of energy infrastructure, improvement of recycling capability, adoption of bio-based plastics and demand management. Increasing decoupling of plastics growth from GHG emissions will be a result of these improvements.[25]

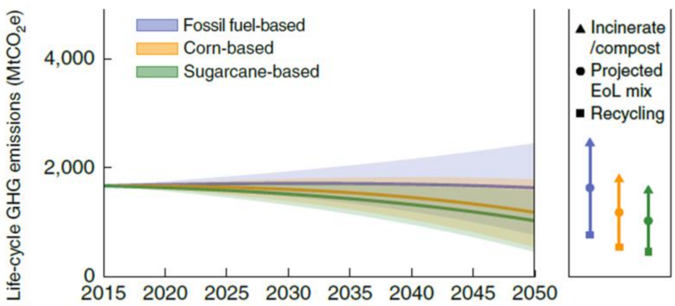

Figure 7: Scenarios for global life-cycle GHG emissions of plastics: Plastics demand grows at 2% per year, energy mix decarbonizes by 2050. Shaded areas represent ranges due to End-of-Life options.[25]

Decoupling GHG emissions from plastic growth will enable to reduce GHG emissions over time despite growing plastic consumption. In addition pages 1 – 3 of this document have shown that GHG benefits of using plastics are often greater than the impacts of producing plastic products and managing plastic waste. Both aspects are crucial for the sustainability assessment of plastics, but are missing in the study of CIEL.

Sustainability of the plastics value chain will have to be improved further in the coming years, especially towards a complete collection and recovery of plastic waste. In addition, the knowledge on impacts and benefits of using plastics will be growing. **We therefore invite interested stakeholders to participate in a dialog and share information which can be considered for the next update of this document.**

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