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Summary of Comparative Life Cycle Assessment of Polyethylene and Alternative Packaging

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Motivation for this study

A Life Cycle Assessment (LCA) to compare polyethylene (PE) based packaging and alternative materials (paper, glass, aluminum, and steel) was conducted by Trayak. The LCA study, which was commissioned by ExxonMobil, is intended to help stakeholders, including decision-makers, better understand certain potential environmental impacts of packaging materials. This summary shares the result of the study which compared plastic and alternative packaging materials following attributional LCA guidelines and in conformance with using ISO 14040 and 14044 standards. The study was critically reviewed by a panel of three independent experts in accordance with ISO 14044, clause 6.3 (ISO 14044, 2006) and ISO 14071 (ISO 14071:2014).

What was studied

This project compared materials for 13 packaged products across five prevalent PE packaging end use applications:

- collation shrink film for multi-packs of either water bottles or body wash
- stretch film for pallet wrap
- heavy-duty sacks containing either dog food or cement
- non-food bottles for cosmetics, shampoo, paint, or motor oil
- flexible food pouches for juice, candy, sauce, or spices

Packaging using PE and alternative materials in each application were modeled using EcoImpact-COMPASS. The following five potential environmental impact categories were assessed: global warming potential (GWP) with biogenic carbon uptake, GWP without biogenic carbon uptake, water scarcity, mineral resource use, and fossil resource use. Data collected included physical samples and supplier specification sheets. Subject matter expertise was used to determine representative packaging applications and typical industry formats. Multiple samples were used when available to calculate an average mass per standard capacity for the package.

Results

The potential reductions, or increases, of impacts associated with the use of PE-based packaging relative to the alternatives (paper, glass, aluminum, and steel) for the 13 packaged products within the five packaging applications are shown in Figures 1-5. Positive values in Figures 1-5 indicate a potential environmental advantage of PE over the alternative materials whereas negative values show an advantage of the alternative materials over PE.

For the 5 potential environmental impact categories and 19 alternative solutions considered in this study, PE based packaging had a lower potential environmental impact in 77 of 95 (81%) of the packaged product comparisons. PE-based packaging showed lower potential impacts in 14 of 19 comparisons for fossil resource use, 15 of 19 comparisons for GWP with carbon uptake, and 16 of 19 comparisons for GWP, mineral resource use and water scarcity.

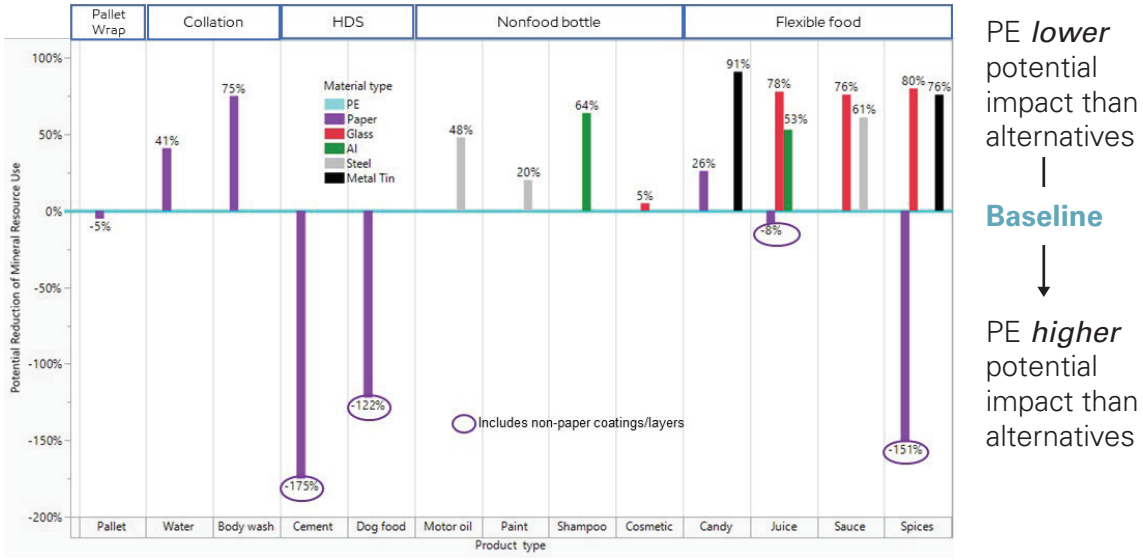


Figure 1: Potential reduction of Fossil Resource Use by PE-based packaging relative to alternative packaging materials. Metal represents tin plated steel.

Figure 1 shows that relative to other packaging materials, PE-based packaging has the potential to reduce fossil resource use (i.e., coal, oil, and gas) in 14 of the 19 packaged product comparisons. Five comparisons show a paper-based alternative with the potential to reduce fossil resource use relative to PE-based packaging; however, four of these five alternatives were paper-multimaterial formats with a PE or other non-paper component used to improve the packaging properties of the system.

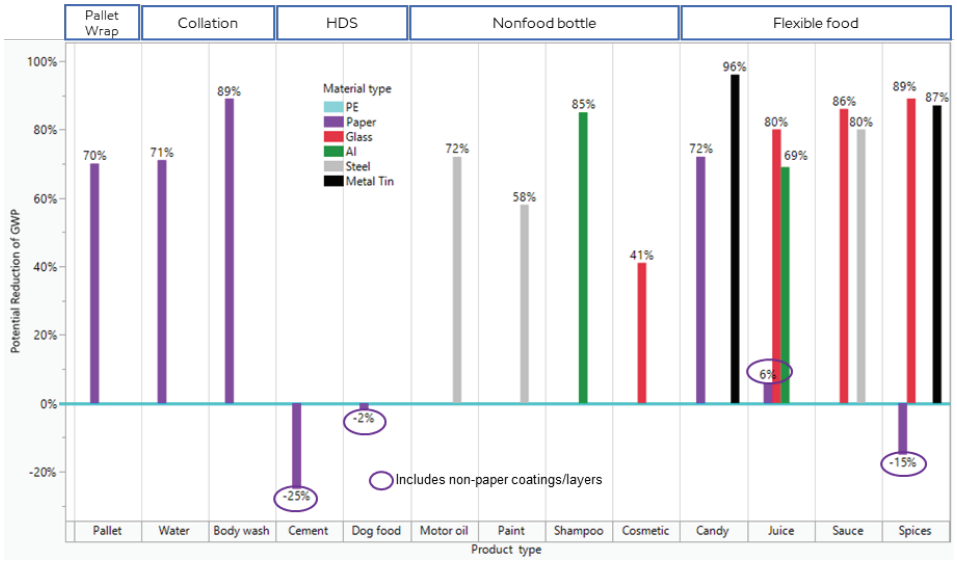


Figure 2: Potential reduction of GWP by PE-based packaging relative to alternative packaging materials.

Figure 2 shows that relative to other packaging materials, PE-based packaging has the potential to reduce GWP in 16 of the 19 packaged product comparisons. The remaining three comparisons are paper-multimaterial formats with a PE or other non-paper component (e.g. other plastics, mineral-based waxes) used to improve the packaging properties of the system.

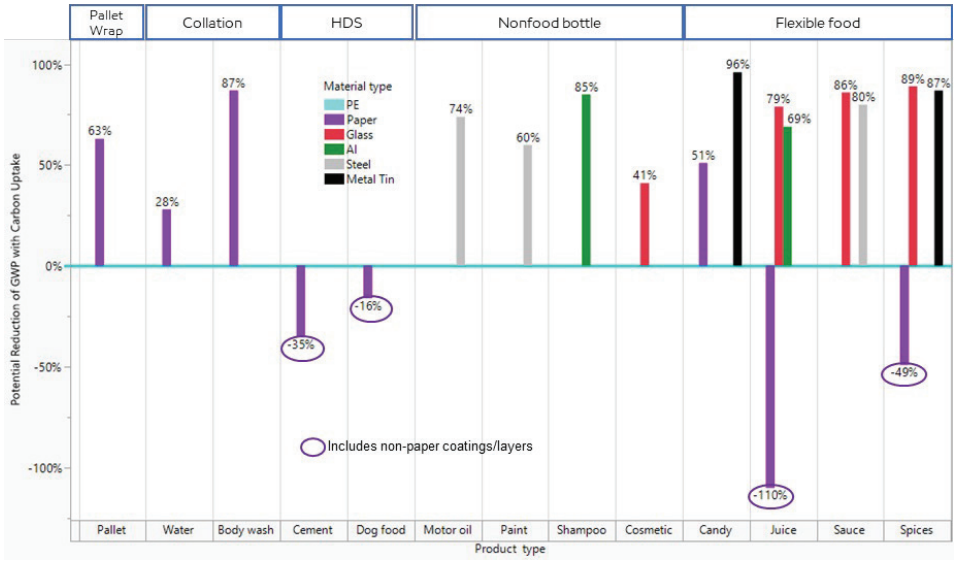
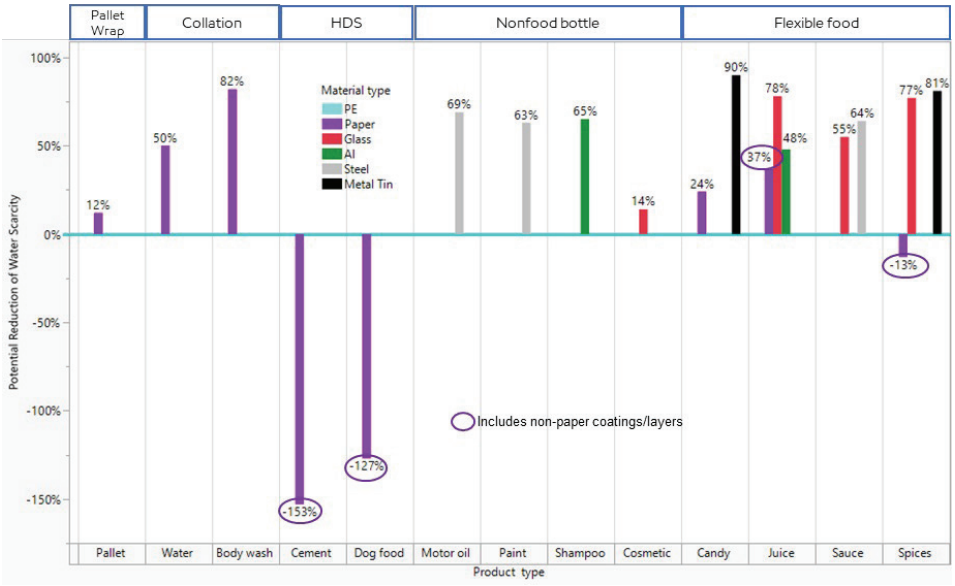


Figure 3: Potential reduction of Global Warming Potential with Carbon Uptake by PE-based packaging relative to alternative packaging materials

Figure 3 shows that relative to other packaging materials, PE-based packaging has the potential to reduce GWP with Carbon Uptake in 15 out of the 19 packaging format comparisons. The remaining comparisons are paper-multimaterial formats with a PE or other non-paper component used to improve the packaging properties of the system.



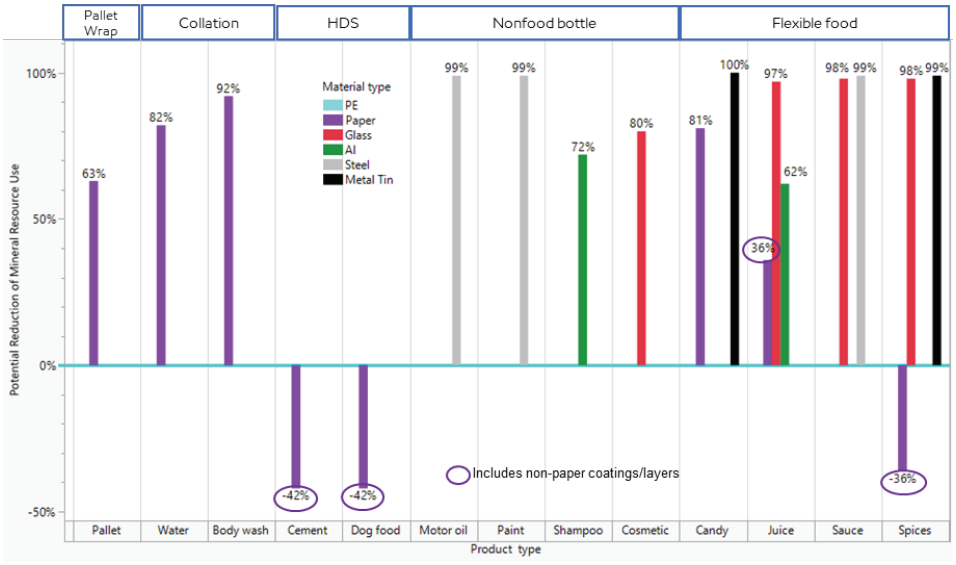
PE *lower* potential impact than alternatives

Baseline

PE *higher* potential impact than alternatives

Figure 4: Potential reduction of Water Scarcity by PE-based packaging relative to alternative packaging materials.

Figure 4 shows that relative to other packaging materials, PE-based packaging has the potential to reduce water scarcity in 16 of the 19 packaged product comparisons. The remaining comparisons are paper-multimaterial formats with a PE or other non-paper component used to improve the packaging properties of the system.



PE *lower* potential impact than alternatives

Baseline

PE *higher* potential impact than alternatives

Figure 5: Potential reduction of Mineral Resource Use by PE-based packaging relative to alternative packaging materials

Figure 5 shows that relative to other packaging materials, PE-based packaging has the potential to reduce mineral resource use in 16 out of the 19 packaging format comparisons. The remaining comparisons are paper-multimaterial formats with a PE or other non-paper component used to improve the packaging properties of the system.

Conclusions

This LCA provided insights that can help inform stakeholders and the public about the potential environmental impacts of PE based packaging as compared to alternative materials such as paper, glass, aluminum, and steel. The following conclusions can be drawn from the study:

- For the five potential environmental impact categories and 19 alternative solutions considered in this study, PE based packaging had a lower potential environmental impact in 77 of 95 (81%) packaged product comparisons. PE-based packaging showed lower potential impacts in 14 of 19 comparisons for fossil resource use, 15 of 19 comparisons for GWP with carbon uptake, and 16 of 19 comparisons for GWP, mineral resource use, and water scarcity.
- The lower potential impact of the PE-based packaging was primarily due to using less material per functional unit as compared to the alternative materials. The largest contribution to the potential impacts is primarily the material extraction, production, as well as conversion of the material into the final packaging component (e.g., fossil fuel used to harvest trees, power paper mills, power chemical plants, etc.). Therefore, the material efficiency of the PE-based packaging translated into the lowest potential environmental impact.
- The potential environmental impacts of PE compared with paper-based packaging are highly dependent on the package weight and design (i.e., the use of plastic or other non-paper components to improve the packaging properties of the system). In certain applications requiring barrier properties and/or heavy-duty applications (e.g., cement or dog food bags), a multi-material paper-based alternative can achieve a lower potential impact in the categories assessed. This reduction in impact is achieved when the weight of the multi-material paper alternative stays below the threshold of 2.5 times the weight of the PE-based packaging. The sole deviation from this conclusion was for pallet wrap, where mono-material paper had a slightly lower fossil resource use than PE.
- For future studies, it is recommended to include use phase performance, damage rates, product losses, and the impact from the packaged products, as these could have significant implications on the conclusions. Increased recycling rates and increased refill and reuse options can also have implications on the conclusions. These aspects were not considered in this LCA due to lack of data.