OBBOTEC-SPEX carbon footprint assessment

Screening life cycle assessment of selective plastic extraction (SPEX)

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Content

Summary

SPEX Technology is a subsidiary company of OBBOTEC, developing a recycling technology called Selective Plastic EXtraction, or SPEX in short. The goal of this screening life cycle assessment (LCA) is to estimate the carbon footprint of recycling three different waste streams with the SPEX process and compare the results to reference plastic production/waste treatment processes.

While this (ex-ante) assessment contains various uncertainties, SPEX recycling is estimated to offer substantial carbon footprint reductions compared to reference processes for all waste streams studied.

Life cycle assessment method

The screening LCA estimates the carbon footprint of SPEX recycling and compares it to fossil production processes (product perspective) and current waste treatments (waste perspective). As no SPEX plant has been built at the 20 kt/yr scale studied here, the (ex-ante) assessment is based on the mass- and energy balances from the conceptual design study of SPEX for the process at full scale and lab tests and pilot tests on smaller 1 kt/yr pilot scale at their location at Plant One Rotterdam. This data is combined with literature data and assumptions for background processes.

Three distinct waste streams are studied as feedstock for SPEX:
1. HDPE from mixed post-consumer waste.
2. Laminate packaging (PP/PET/aluminium) from mixed post-consumer waste.
3. Medical breathing tubes (PP/LDPE/copper).

Product and waste perspective

The SPEX technology has two functions: treatment of plastic waste and production of new plastics. Therefore, the carbon footprint of the technology is analysed from two perspectives: the waste perspective and the product perspective.

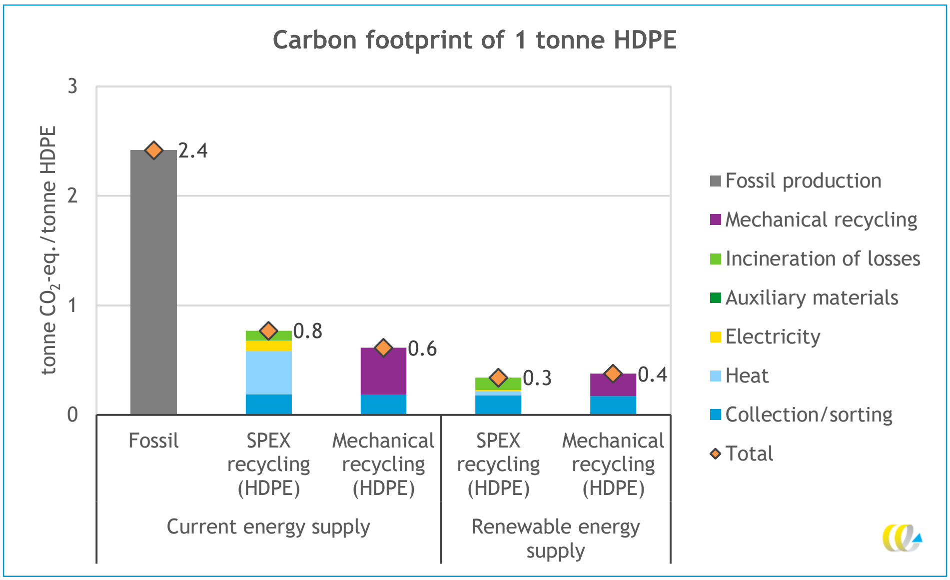
In the **waste perspective**, the treatment of plastic waste streams by SPEX is compared to conventional waste treatment technologies (incineration, mechanical recycling). This perspective is relevant for policymakers interested in comparing the environmental implications of treating waste in different installations. To account for the different products (plastics or energy) of these processes, a substitution approach is applied.

In the **product perspective,** the production of plastics by SPEX is compared to conventional plastic production (from fossil feedstock or by mechanical recycling). This can be used in business-to-business communication with parties interested in sourcing recycled plastics produced by SPEX. A credit for avoided waste incineration is not included.

Detailed results: HDPE from mixed post-consumer waste

Figure 1 shows the product perspective results for the first waste stream, HDPE from mixed post-consumer waste. It compares the carbon footprint of 1 tonne of HDPE produced by SPEX, mechanical recycling and from fossil resources (newest ecoinvent data). The left three bars show the results when using the current average energy supply. The right three bars show the results when a renewable energy mix is used for SPEX recycling and mechanical recycling.

Figure 1 - Carbon footprint of HDPE production (cradle-to-gate) - recycling of HDPE waste



The carbon footprint of HDPE produced via SPEX is substantially lower (a reduction of 1.6 t CO_2-eq./t) than the carbon footprint of fossil HDPE. The carbon footprint reduction is increased further (2.1 t CO_2-eq./t) with a renewable energy mix. Compared to mechanically recycled HDPE, the carbon footprint of HDPE from SPEX recycling is estimated to be slightly higher with the current energy supply. When using renewable energy, the carbon footprints are comparable.

With the current energy supply, the carbon footprint of the SPEX technology stems primarily from the use of heat and the collection and sorting processes. The use of electricity and the incineration of losses make up the rest of the carbon footprint.

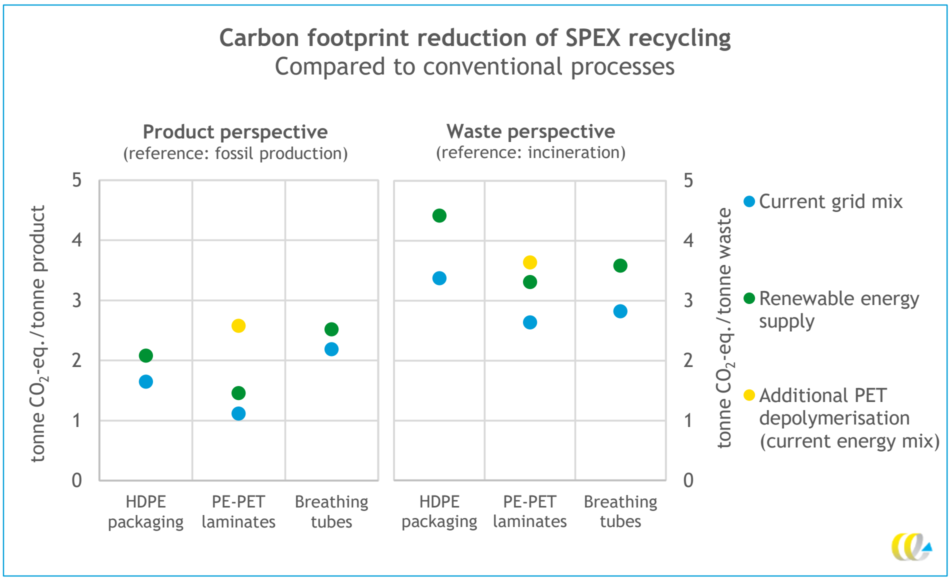
Detailed results for the other feedstocks as well as the waste perspective are available in the full report.

Overview of all carbon footprint results

In Figure 2, the carbon footprint results for all studied cases are summarized. The figure shows the carbon footprint reduction achieved by SPEX recycling compared to fossil production or incineration.

Note that in this graph, higher values represent larger carbon footprint reductions.

Figure 2 - Overview of estimated carbon footprint reductions of SPEX recycling, per tonne output (product perspective) or per tonne waste input (waste perspective)



The left side of Figure 1 shows product perspective results. The analysis shows that SPEX recycling offers a substantially lower (1.1 to 1.9 t CO_2-eq./t) estimated carbon footprint than fossil production of polyolefins (product perspective analyses, current energy mix). This reduction is increased further to 1.5 to 2.2 t CO_2-eq./t when assuming renewable energy supply for SPEX.

The reduction is largest when treating medical breathing tubes, which can be fully recycled with SPEX dissolution (closed-loop recycling). In contrast, the reduction is smallest for packaging laminates, where PET and additives are lost to incineration. However, if the PET waste (28%wt. of the feedstock) can be recovered by combining SPEX with a PET depolymerisation plant, the carbon footprint reduction increases substantially.

The right side shows the waste perspective results. Here, the estimated carbon footprint reductions achieved by SPEX follow the same trends. However, the reductions are higher, as these results also include a credit for avoided fossil production of the recovered materials (see discussion below). The waste perspective reductions range from 2.6 to 3.4 t CO_2-eq./t waste treated when using the current energy mix, and 3.3 to 4.5 t CO_2-eq./t waste treated when using renewable energy for SPEX dissolution. These reductions are comparable to those achieved by mechanical recycling.

Uncertainties and recommendations

The screening LCA contains some important assumptions and other limitations. These can be addressed in future updates to increase the robustness of the conclusions presented here. Key limitations are:

- The analysis is primarily based on SPEX process data projected for 20 kt/yr operation. Once in operation, it is important to validate this data (energy consumption, solvent recovery rates, mass balances, etc.) in full-scale practice.
- The first product perspective analysis compares SPEX, mechanical recycling and fossil production routes of 1 tonne PE. However, the quality/purity of the products may not be fully identical and there can be regulatory limitations affecting whether a specific

product can be used in specific applications (e.g. food contact). While the outputs of all three systems are likely interchangeable in many applications, it is relevant to consider quality differences in greater detail when analysing specific product applications.

- The screening LCA contains various assumptions and use of background data, which can be improved in future updates.
- This screening study focuses on the carbon footprint performance of different technologies. Additional environmental indicators can be included in a more extensive LCA.