Summary of Ioniqa LCA

Screening carbon footprint analysis

CE Delft

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Authors:
Erik Roos Lindgreen
Geert Bergsma

Delft, CE Delft, August 2018

Publication code: 18.2P42.104

Client: Ioniqa Technologies and Municipality of Rotterdam

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More information on this study can be obtained from project leader Geert Bergsma (CE Delft)

1 Introduction and methodology

1.1 Introduction

Ioniqa is a clean-tech startup from Eindhoven working on development and production of Magnetic Smart Materials. One of the key applications of these materials is chemical recycling of PET waste that is hard to mechanically recycle to yield a high-quality product, particularly because of fouling with colouring agents and other plastics. In the Ioniqa process PET from at-source or post-consumer separation is used to produce BHET, an intermediate in PET production. The Ioniqa technology means PET waste can be recycled to make new high-quality products. Ioniqa PET can also be used in food applications. A 10,000 metric tonne per year (mtpa) production facility is planned for 2018.

CE Delft was asked to analyse the carbon footprint of the Ioniqa technology. To this end a screening LCA of the principal process steps was carried out. The main aim of this analysis was to obtain a basic understanding of the environmental impact of the Ioniqa technology relative to current waste processing technologies: incineration in a waste-to-energy (W2E) plant and mechanical recycling. In addition, the production of PET from BHET via the Ioniqa technology was compared with conventional production of PET using fossil feedstocks.

This document is a summary of the complete, confidential report and provides information on the methodology adopted and the results obtained. The original report was confidential for considerations of competitiveness.

1.2 Method: screening LCA

This screening LCA seeks to provide insight into the environmental impact of the Ioniqa technology, specifically a comparison of the carbon footprint of PET produced using Ioniqa's output with that of PET conventionally produced from petroleum. The analysis also provides a first-pass indication of how the Ioniqa technology compares with other waste processing methods like mechanical recycling and incineration in a W2E plant.

A screening LCA is a simplified attributional life-cycle assessment (LCA) encompassing the main inputs and outputs. In this case the environmental impacts considered are restricted to the process' contribution to climate change, in short: its climate impactor carbon footprint. Other LCA studies have demonstrated that when it comes to energy and plastics, the carbon footprint is the dominant environmental impact and is a good proxy for differences in overall environmental performance.

Screening LCAs provide early information on a technology's probable environmental footprint, and thus enable to support initial (cautious) policy decisions on technologies that have not yet reached full development. The drawback of this simplified approach are the greater uncertainties involved and its restriction to just a single environmental indicator. Because chemical recycling technologies are still in development, there is often only limited data available on how these (would) perform on an industrial scale. This means it is not always possible to carry out extensive LCAs. The screening LCA method works with the principal inputs and outputs of a process. It is therefore important to be aware of the uncertainties and attempt to reduce these as the technology is further developed. This can be done by continual tweaking of the analyses and a steady progression towards a detailed LCA.

1.3 Background: three different comparison methods

For this screening LCA of the Ioniqa technology three different comparisons were carried out:

1. **Linear comparison from a waste perspective,** analysing processing of 1 tonne of PET waste by Ioniqa and comparing this with mechanical recycling and processing by incineration in an average Dutch W2E plant. This method is in line with Dutch waste policy, as set out in the 3rd National Waste Management Plan (LAP3), for example, and proceeds from the question of how a given volume of waste can best be processed.

2. **Multicycle comparison**, modelling processing of 1 tonne of PET waste by Ioniqa over two processing cycles and doing the same for mechanical recycling. This method is also waste-oriented, but is more concerned with the objectives envisaged in a circular economy. It also considers how the waste from the product from the first recycling cycle is to be processed. This approach is cited as being an innovative LCA approach in LAP3 and dovetails more with the philosophy of the circular economy, which seeks to keep resources circulating as long as possible. This analysis thus takes into due account that the material generated by the Ioniqa process is reused in packaging that is later fed back into the process as waste.

3. **Product comparison**, analysing production of 1 tonne of PET by Ioniqa and comparing this with production of 1 tonne of conventionally produced PET from fossil feedstocks. This method assigns the environmental footprint to the recyclate that is ultimately made from the waste PET. This comparison is suitable for comparing products produced from waste, both mutually and relative to their virgin counterparts.

2 Results

2.1 Summary

As set out in Section 1.3, three different comparisons were performed. Because the Ioniqa process allows PET to be recycled indefinitely, the second of these methods is the most relevant. The lowest carbon footprint is obtained when the process is implemented on an industrial scale (50,000 mtpa).

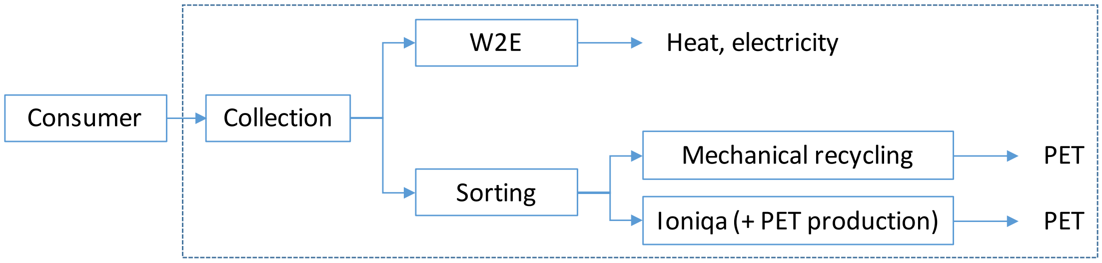
In a (linear) comparison with fossil-based PET, the Ioniqa process has a 75% lower carbon footprint.

2.2 Linear comparison from a waste perspective

Background

In the linear comparison the Ioniqa process is regarded as a waste processing technology and is therefore compared with the technologies currently employed for processing PET waste: incineration in in an average Dutch waste-to-energy (W2E) plant producing both heat and power, and mechanical recycling. In the schematic flow-chart below the arrows represent the PET post-consumer waste stream ending up at the processing plant.

Figure 1 - System boundaries, linear comparison



With mechanical recycling some fraction of the input is likely to be lost in practice, particularly in the case of streams that are hard to recycle mechanically like PET trays, which are Ioniqa's focus. Real-world mechanical recycling losses are unknown, one reason being that relevant technologies are still under development. In our analysis we have worked with a range from 0% to 20% loss.

Results, linear comparison

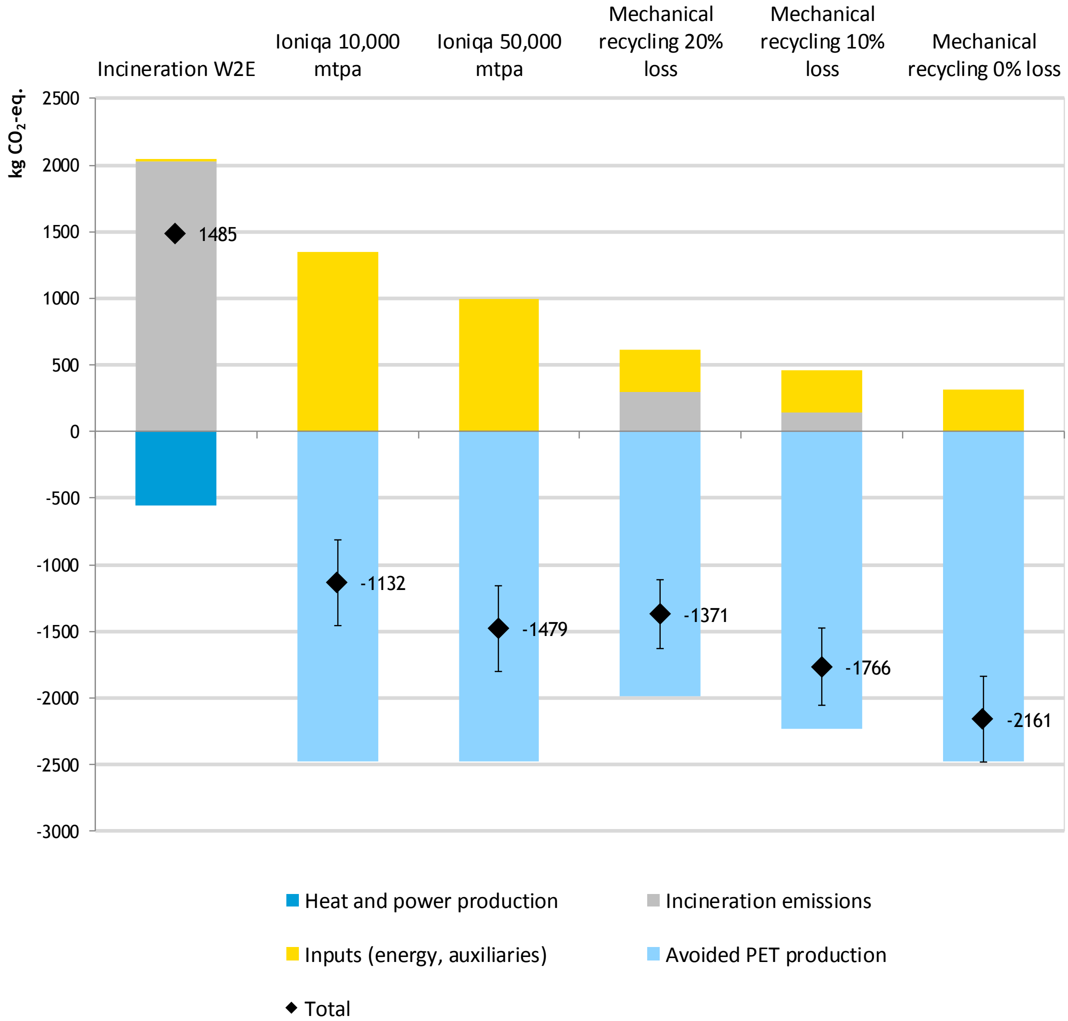
The overall result has two components: first, the CO_2 emissions due to incineration and consumption of energy and auxiliaries; second, the avoided CO_2 emissions due to heat/power production and avoided PET production.

With mechanical recycling, some fraction of the material may be lost that subsequently goes to the incinerator, for which we took a range from 0% to 20%. The Ioniqa technology can be implemented at various scales; we worked with two variants: 10,000 mtpa and 50,000 mtpa.

In the 10,000 mtpa variant mechanical recycling performs better, regardless of the processing losses. In the 50,000 mtpa variant Ioniqa performs on a par with mechanical recycling when losses in the latter are around 15%. With lower losses, mechanical recycling performs better.

These results indicate that the Ioniqa technology is a good option for waste streams that cannot currently be mechanically processed or are not captured by this process. If such streams would otherwise be incinerated in a W2E plant, there are major environmental benefits.

Figure 2 - Results, linear comparison of incineration, Ioniqa and mechanical recycling. Functional unit: processing of 1 tonne PET waste



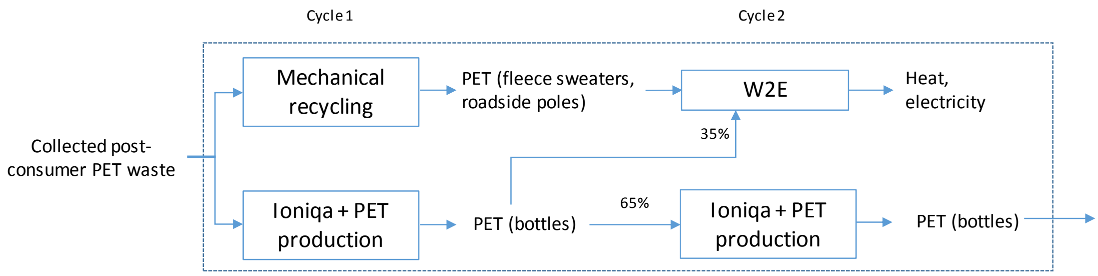
2.3 Multicycle comparison

Background

In the second comparison Ioniqa is also seen as a waste processing technology and this route is compared with processing by mechanical recycling, now over two cycles in both cases. This comparison was made to obtain a quantitative figure for the environmental benefits of the high-quality Ioniqa output relative to the mechanical recycling output.

In this comparison the following assumptions were made:
- The output from mechanical recycling is not collected again for recycling after another cycle. It is used mainly in non-packaging applications like fleece sweaters for which a less stringent recycling regime is in force. Such products are recycled to only a limited extent, with most ending up in an incinerator after disposal.
- A greater fraction of the bottle-PET produced by Ioniqa is eventually collected and sorted for recycling. Based on information from Nedvang this fraction was taken to be 65%, with the other 35% also ending up in the incinerator.

Figure 3 - System boundaries, multicycle comparison



Results

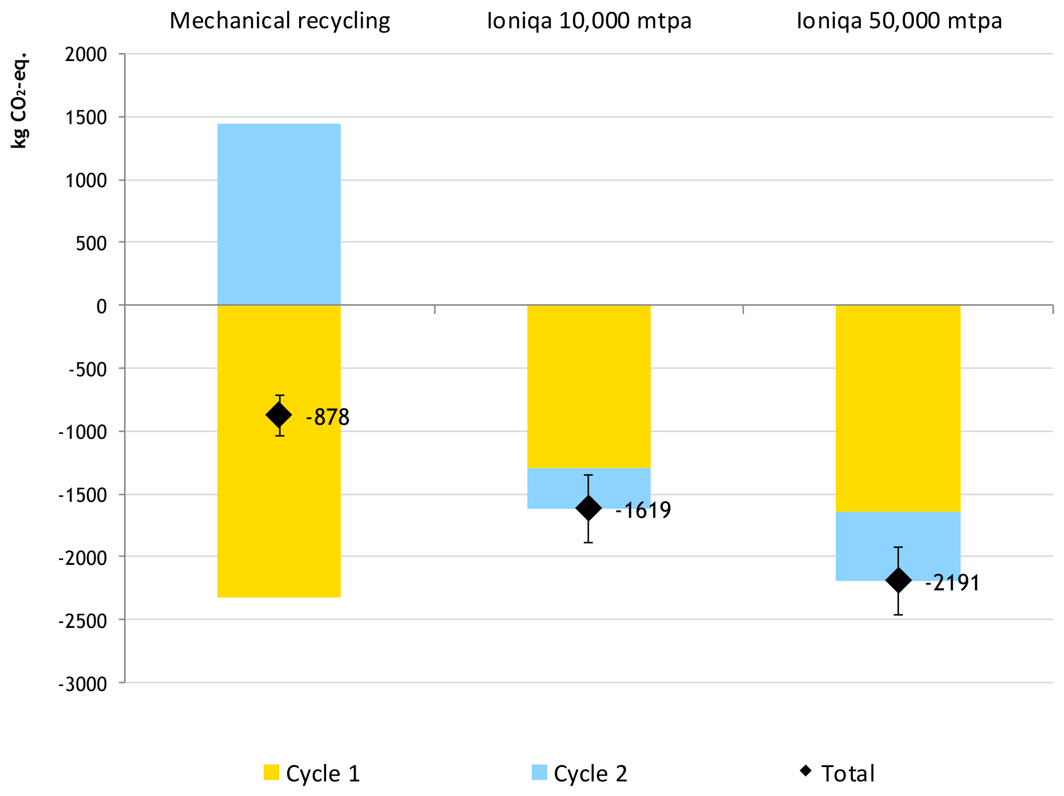
The results of the multicycle analysis show that a downside of mechanical recycling is its lower-quality output compared to that of the Ioniqa technology. The Ioniqa product can be used again in PET bottles, whereas the material from mechanical recycling can only be used for fleece sweaters or other lower-grade plastic products. This proceeds from the assumption that the output is incinerated after one cycle.

For the Ioniqa process, it is assumed that the output is virgin quality and is again used to produce PET bottles. If these are large bottles, 95% of them will be recycled; if they are small bottles this will be around 65%. To err on the conservative side we assumed small bottles, so that a fraction of about 35% will still be incinerated and not end up at a recycling plant. From the perspective of a multicycle circular economy, even restricting the analysis to just two cycles, the Ioniqa route is clearly superior in environmental terms because the bottle-to-bottle route leads to a second round of recycling.

The methodology developed for LAP3 suggests analysing three cycles. If we were to do so, the benefits of the Ioniqa route would be even greater.

In this multicycle comparison no additional loss percentage was included in the model for mechanical recycling, though this is certainly conceivable for hard to recycle waste streams like PET trays. Our analysis of the Ioniqa process is therefore conservative.

Figure 4 - Results, multicycle comparison of Ioniqa and mechanical recycling. Functional unit: processing of 1 tonne PET waste over two cycles

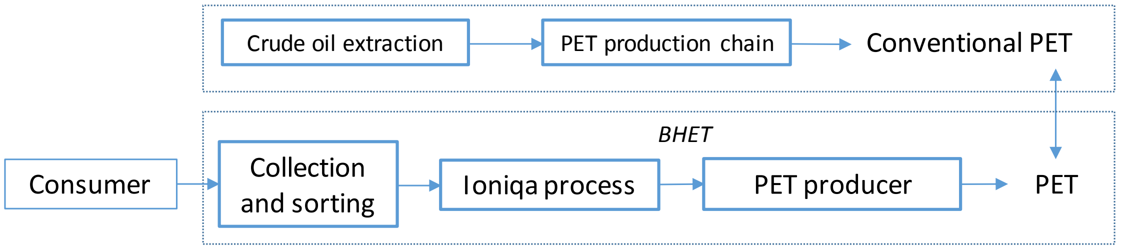


2.4 Product comparison

Background

In the product comparison Ioniqa is regarded as a PET producer, with the output of the Ioniqa process (including the extra step of BHET to PET conversion) being compared with conventionally produced PET. The analysis considers the entire PET production chain. In addition, a comparison is made with PET from mechanical recycling.

Figure 5 - System boundaries, product comparison.



Results

This last comparison shows that production of conventional, petroleum-based PET has a CO_2 emission of around 2.5 tonnes per tonne of PET. If end-of-life incineration emissions are also included, the figure is slightly below 4 tonnes CO_2 per tonne PET.

If Ioniqa is seen as a PET producer, the result depends on how the incineration that is thus avoided is allocated. If it is allocated to Ioniqa, their PET is associated with a CO_2 emission of 1 to 1.3 tonnes per tonne of PET from Ioniqa BHET, depending on plant capacity.

Because of the lower energy inputs, PET from mechanical recycling performs better. The difference depends on the percentage loss of PET going to incineration. This ignores the advantage of better-quality output being obtained.

Figure 6 - Results, product comparison of Ioniqa and conventionally produced PET. Functional unit: production of 1 tonne PET