

Fast Track Life Cycle Analysis of an air mattress – Sam Ninaber van Eijben

This report has been drawn up in December 2023 and it is reviewed by J. G. Vogtländer

1. Introduction

Life Cycle Analysis (LCA) is an effective analysis tool to assess the environmental impacts of a product or system at all stages of its life. This report uses a Fast Track LCA analysis [4] and aims to determine the environmental profile of the commonly used polyvinyl chloride (PVC) air mattress. We will compare this LCA to a LCA of a polyethylene (PE) air mattress.

On multi day (music) festivals with a campsite for its visitors 38% of the total waste production comes from left behind camping gear. And this waste is incinerated in the Netherlands [1].

Most airbeds used on the festivals are made from polyvinyl chloride (PVC). These air mattresses are destined for incineration, with several undesirable downstream effects; they affect eco-systems and the environment, but also human health and global warming. The negative effects of PVC led the European Commission to consider a restriction proposal, which could lead to a ban of these substances [2]. Other airbeds are also not being recycled because of several other challenges [3]. This will be discussed in the Life Cycle Impact Assessment (LCIA).

The air mattress-system from OOMPH Industries® that is brought to market under the Zzz Land® brand uses a recyclable plastic mattress, composed of two parts: an inflatable film and a pillowcase. The Zzz Mattress is made for the most part of polyethylene (PE), which is considered a safe and recyclable plastic. Zzz Land's purpose is to reduce the large amount of trash left behind at festivals, to protect the world's eco systems and to empower consumers to choose responsibly.

2. Goal and Scope Definition

2.1 Goal of the study

2.1.1 Reasons for carrying out this study

The purpose of this LCA is to determine the environmental profile of PVC air mattresses with the aim of identifying the most damaging environmental processes so that alternatives can be proposed (for example, alternative processes, alternative products). This LCA will be compared to the alternative mattress from Zzz Land.

2.1.2 Intended audience

The intended audience of this LCA comprises (1) everyone that camps at festivals, and (2) the organizer of festivals so that they can be made aware of the most harmful processes and decision in regards to these matters can be made based on data.

2.2 Scope of the study

2.2.1 General description of the systems in scope

For the PVC air mattress, we have chosen the Intex® DURA-BEAM STANDARD™ (Figure 1), to base our LCA on, and we will compare this to the Zzz Mattress (Figure 2).



Figure 1

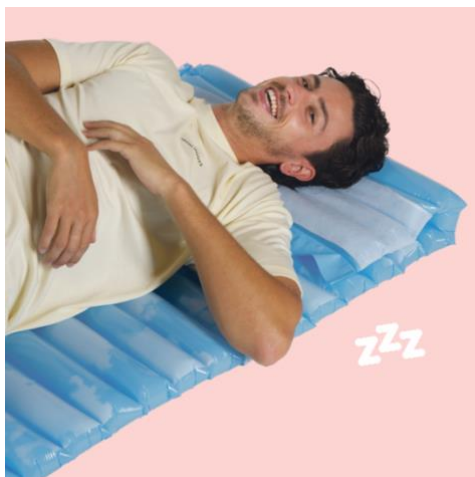


Figure 2

2.2.2 System functions

PVC used in air mattresses is a synthetic polymer of plastic made flexible with plasticizers. It comes with attractive properties: it is colourless, soft and flexible, and can be welded together with heat. This makes it a good candidate to satisfy the product function: 'short-term sleeping off the ground'. The Intex® mattress can be inflated and deflated for repeated use and consists of 1 large air-chamber.

The product function of the Zzz Mattress is equal to that of the Intex® mattress: to allow for 'short-term sleeping off the ground'. It is not designed for deflating and re-inflating but designed for recycling after use.

2.2.3 Declared Unit

The Declared Unit (DU) will be defined by 'per mattress':

Single person air mattress, per mattress

2.2.4 System map and system boundary, and cut off criteria

Figure 3 and Figure 4 show the systems flows of the life cycle of a PVC air mattress, and the Zzz Mattress, respectively. Our LCA system is based on the gate-to-cradle aspects of the life cycle (i.e. from manufacturing to end of life). This is included within the system boundaries of our LCA and comprises: the raw material, the air mattress manufacturing process, the international transport process (of the product itself) and the end of life. The end of life includes the recycling or the disposal of the air mattress by means of incineration.

The cut-off criteria (i.e. the stages excluded from the system boundaries) will be: the raw material (RM) transportation, the manufacture of machinery parts, local transport, the use phase, the manufacture of vehicles used for transportation and the wholesale and retail processes. In the case of the PVC air mattress, any of the production processes and transport that we have no data on will also be excluded from the system boundaries.

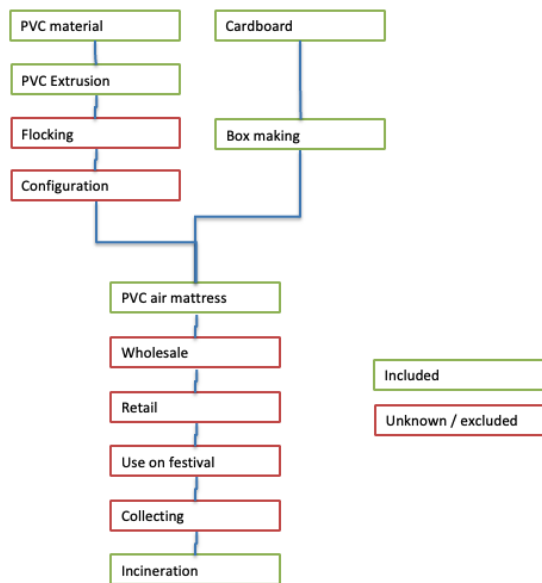


Figure 3 Flow of PVC air mattress

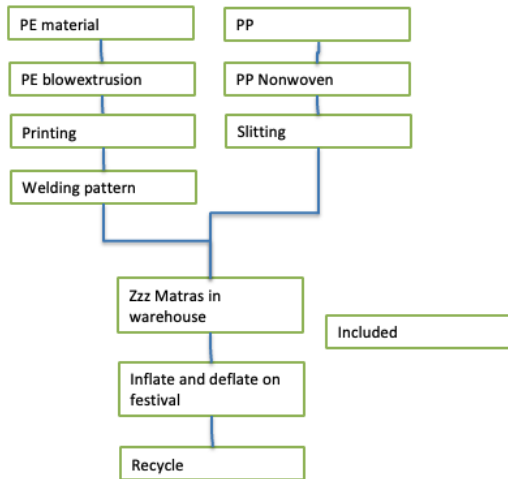


Figure 4 Flow of Zzz Mattress

2.2.5 Allocation rules

In the Netherlands, the waste stream from the festival camping ground is incinerated. We assume that the box that the PVC air mattress comes in is also left on the camping ground and thereby also incinerated as part of a larger waste stream.

The Zzz Mattress is comprised of PE, EVOH and PP. All of these are collected and together recycled within the same chemical recycling process.

2.2.6 Data collection procedures

Data for our LCI was obtained from Idemat 2023 database. Data for the PVC air mattress was obtained from the Intex® official website (<https://intexcorp.com>) and by means of weighing the product. The data for the Zzz Mattress was obtained from the technical drawings and data provided by the manufacturer.

2.2.7 Key assumptions

The assumptions of our LCA will be as follows:

- The Zzz Mattress can last a full festival and is returned after its use.
- The PVC air mattress is left behind at the festival camping ground.
- The entire PVC air mattress is made only from PVC.
- In the production of the Zzz Mattress there is a production loss of 5%
- In the production of the PVC air mattress there is a production loss of 10%
- The mode of intercontinental transport is by container ship from Xiamen (P.R. China) to Rotterdam (the Netherlands).

Table 2

Transport		Eco-Intensity (impacts/ ton-km)	Mass per item (ton)	Distance per item (km)	Uncertainty %	Notes	Calculated Impact
Shipping from Xiamen to Rotterdam	Idemat2023 Container ship (r	0,0006	0,00253	21000	10%		0,03031
							0
							0
							0
							0
							0
total transport						€	0,03

By absence of clear data, we decided to not take the local transport into account.

End of life

Table 3

End of Life		Eco-Intensity (impacts/kg)	Mass per item (kg)	Items per func.unit (#)	Uncertainty %	Notes	Calculated Impact
Incineration of PVC	Idemat2023 PVC (Polyvinylcl	0,97	2,53	1	10%		2,44801
Incineration of a dry box	Idemat2023 Paper, Cardboan	-0,11	0,23	1	10%		-0,02511
							0
							0
							0
							0
							0
							0
							0
							0
							0
							0
total end-of-life						€	2,423

In The Netherlands the PVC is incinerated in an electrical power plant. As the production loss in China is unclear, we selected the most optimal scenario: incineration in an electrical power plant.

Total eco-costs

Table 4

	Declared Unit	
Manufacturing	€	2,03
Transport	€	0,03
End of Life	€	2,42
Total	€	4,49

Life Cycle Inventory of the Zzz Mattress

Manufacturing and processing

The weight of the film is 200g and measure 4,329m². It is made from at least 50% raw material supplied by SABIC in The Netherlands. The manufacturing process comprises a blown-film extrusion process and a 30% one-sided print, executed at Oerlemans Packaging in The Netherlands. The chemical composition of the film is PE/EVOH/PE at a thickness of 50mu. The film is converted into the final mattress on roll with a welding procedure at StoroPack in Germany. With this production method an estimated 5% production loss is calculated in production and End of Life.

3.2.3 Unit of measure (CO₂-eq, eco costs, other)

The standardized unit will be in terms of cost to the environment – i.e. the eco-costs (defined in this LCA as €/DU). The eco-cost is defined by Vogtländer as: “the costs of the environmental burden of a product on the basis of that burden.” [4] In other words, they are the costs required to offset the environmental burden (pollution, material depletion, etc.) of a product, system or process.

We chose the eco-costs because we wanted to see the full picture of the impact to the environment, rather than only CO₂ emissions.

4 Impact analysis

PVC is generally considered a health hazard and a toxic risk for our planet. In these calculations, it is clear to see that a PVC air mattress indeed comes with a high eco-cost in both the Manufacturing and End of Life phases of its lifecycle.

With the calculation of the eco-costs of the PVC air mattress (4,490 €/DU) and the calculation of the Zzz Mattress (0,147 €/DU) we can calculate how many festivals a PVC air mattress should last before it compares to the same eco-costs of the Zzz Mattress on every one of those festivals.

$$4,490 \text{ €/DU} / 0,147 \text{ €/DU} = 30,5 \text{ festivals}$$

For the visitors that buy a new PVC air mattress for every festival they visit, the following reduction in eco-costs are achieved when interchanging that behaviour for a Zzz Mattress.

$$(4,490 \text{ €/DU} - 0,147 \text{ €/DU}) / 4,21 \text{ €/DU} \times 100 = 96,7\% \text{ reduction}$$

5. Conclusions and recommendations

Discussion

In theory an air mattress that can be deflated and inflated many times sounds like a great option. In the actual situation of a (music) festival, it unfortunately does not prove to be feasible to keep an air mattress intact and functioning for very long. Even a minor puncture results in a critical failure and the product immediately loses its functionality. The whole product is deemed to be unusable and is discarded as festival waste.

The Zzz Mattress uses over 90% less material. It is designed with multiple air chambers, so when one or several chambers get punctured, the remaining chambers still maintain the products function. Recycling is incorporated in the product-service approach.

The Zzz Mattress may be perceived as a ‘single use’ item. Festival campsites however provide a controlled environment in which the material stream coming out of the camping ground can be managed. Therefore, a product that is designed for recycling can also in reality be recycled.

The recycling process that is currently used for the Zzz Mattress consumes more energy than mechanical recycling. At the time, mechanical recycling is not yet at a quality level that it can renew the material in a way to not degrade the quality. It could well be that this changes in the future.

Conclusion and recommendations

Our LCA goal was to determine the environmental profile/LCA of a PVC air mattress from Intex®, and to compare this to the environmental profile/LCA of the Zzz Mattress. This is with the hope of replacing the more harmful processes with less harmful ones, or to encourage the reduction of the use of PVC air mattresses as disposable items by the festival visitors.

We now have an indication of both profiles and can draw the conclusion that the Zzz Mattress that is recycled after every festival provide the possibility to lower the environmental footprint of the festival campsite. As an alternative, we may advise that visitors should use their PVC air mattress on at least 30,5 festivals before purchasing a new one.

6. References and appendices

[1] <https://www.greenevents.nl/wp-content/uploads/2023/01/Factsheet-Grondstoffen-Materialen-MOJO-2030-kl-170123-1-724x1024.png>

[2] <https://www.theguardian.com/environment/2022/apr/25/eu-unveils-plan-largest-ever-ban-on-dangerous-chemicals>

[3] <https://www.kvk.nl/businesschallenge/challenges/viewChallenge/6cb2cbe0-0170-4dc0-ab23-ecdc006343a2>

[4] J. G. Vogtländer (2023). *LCA, a practical guide for students, designers and business managers*. ISBN 97890-8333-6008