LCA results summary for comparison of Prusament PETG/PLA and their Recycled variants

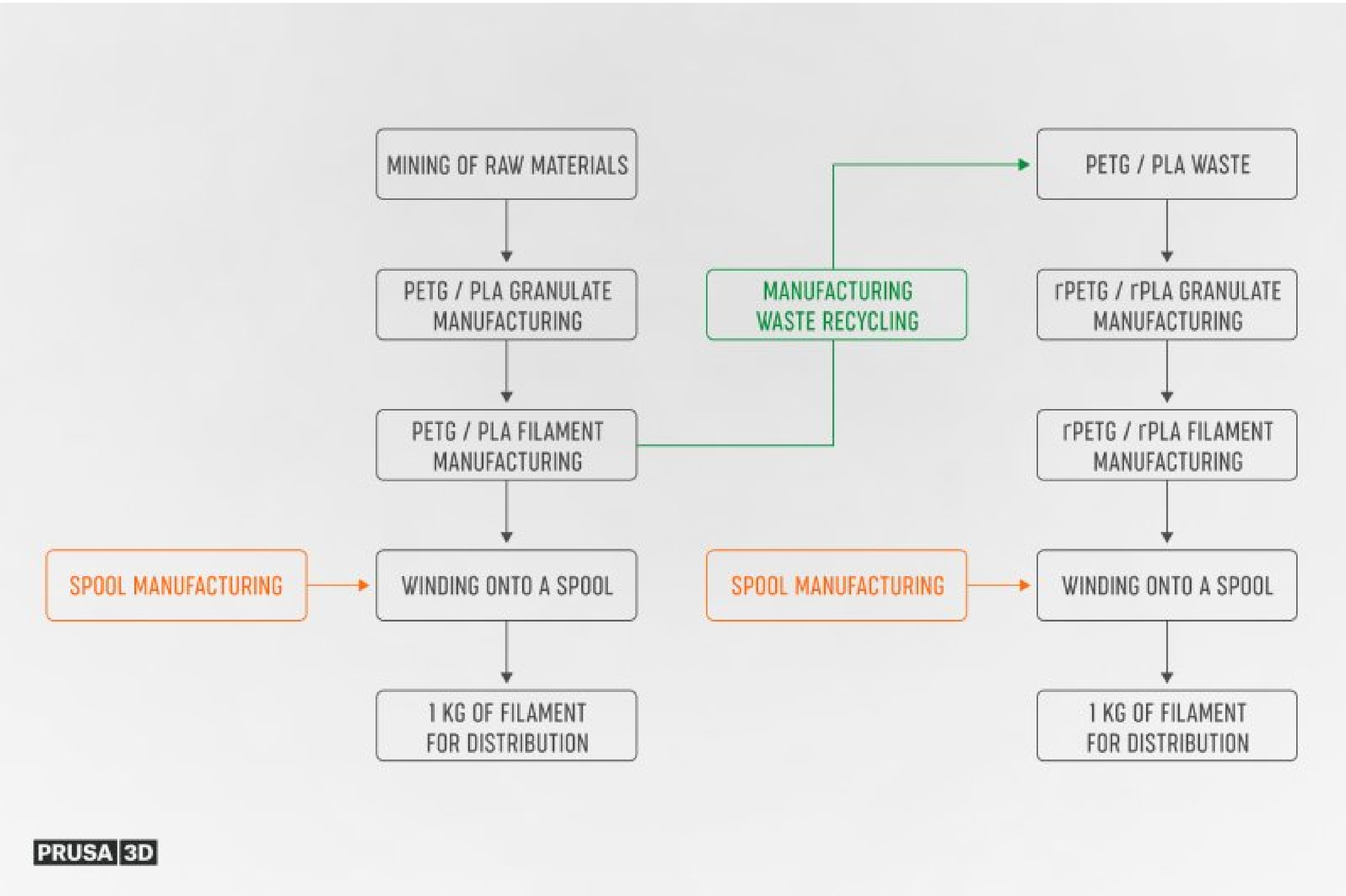
1. Introduction

This study assesses the life cycle of filaments used in 3D printing technology. The studied materials were PETG and PLA, with assessment in the production system ranging from obtaining raw materials to filament production. The goal was to assess environmental impacts and their causes within assessed systems in such a way that would make it possible to use the findings to reduce the environmental impacts of filaments. A part of this study was also a comparison of LCA for PETG made from the primary resource with results for PETG made from recycled material, along with the comparison of the environmental impact of PLA made from primary resources with results of PLA made from recycled material.

- **System boundaries** were selected for filaments made from primary resources to include raw material excavation, their processing and filament manufacturing, including energy and additive resources, and also filament manufacturing and winding on a spool. For the recycled filaments, the boundaries included collecting manufacturing waste, its processing and filament manufacturing, including energy, and winding on a spool. The spool manufacturing was also a part of the system boundaries. Filament and spool distribution, their usage and disposal were not included in the system due to the selected goal, which was the comparison between Prusament and Prusament recycled.
- Since the scope of the system did not involve the use of the product after the end of its lifespan, the functional unit was not defined. Instead, the only declared unit was specified as 1 kg of filament.
- The study results are valid for the year 2021 when the study was performed. It will be valid if there are no changes in primary data, for example by changing or modifying technology, by changing resources/material and/or by changing other processes in the company, but also by changing energetic mixture and other processes outside the company.

2. Flowchart

The flowchart was based on real flows for the production of 1 kg of filament made from PETG or PLA primary resources and on making 1 kg of filament from PETG or PLA waste.



Img. 1 The schematic shows parts of the life cycle of Prusament PETG and PLA made from primary resources, ranging from obtaining resources to finishing the product. The schematic shows the way of generating waste, collecting waste and reuse as a secondary resource for making Prusament PETG Recycled and Prusament PLA Recycled. The schematic presents the life cycle of manufacturing recycled Prusaments, ranging from collecting waste to finishing the product.

- **Notes**

The calculations for Prusament PETG Recycled material were based on zero market value of the waste. The entire environmental load is therefore carried by the previous life cycle. The waste material used here was previously incinerated, so the production of the recycled filament has moved the waste one level higher in the waste disposal hierarchy. The use of energy from previous waste incineration was taken into account in this LCA study.

We didn't have our own data for the material used to produce spool faces since we bought it from another supplier. Here, we took data from the database to calculate LCA.

3. Selected impact categories

Table 1 Result summary for selected impact indicators for PETG and PLA in %.

Impact category	Prusament PETG	Prusament rPETG	Prusament PLA	Prusament rPLA
Abiotic Depletion - minerals and metals (AD)	53.06 %	8.92 %	100 %	8.85 %
Abiotic Depletion - fossil fuels (AD FF)	100 %	19.72 %	60.69 %	19.93 %
Global Warming (GWP100a)	100 %	43.5 %	98.53 %	42.18 %
Ozone layer Depletion Potential (ODP)	88.62 %	20.38 %	100 %	20.7 %
Photochemical Ozone Creation Potential (POCP)	100 %	27.39 %	78.9 %	27.89 %
Acidification Potential of soil and water (AP)	93.66 %	31.84 %	100 %	32.28 %
Eutrophication Potential (EP)	79 %	55.5 %	100 %	55.26 %

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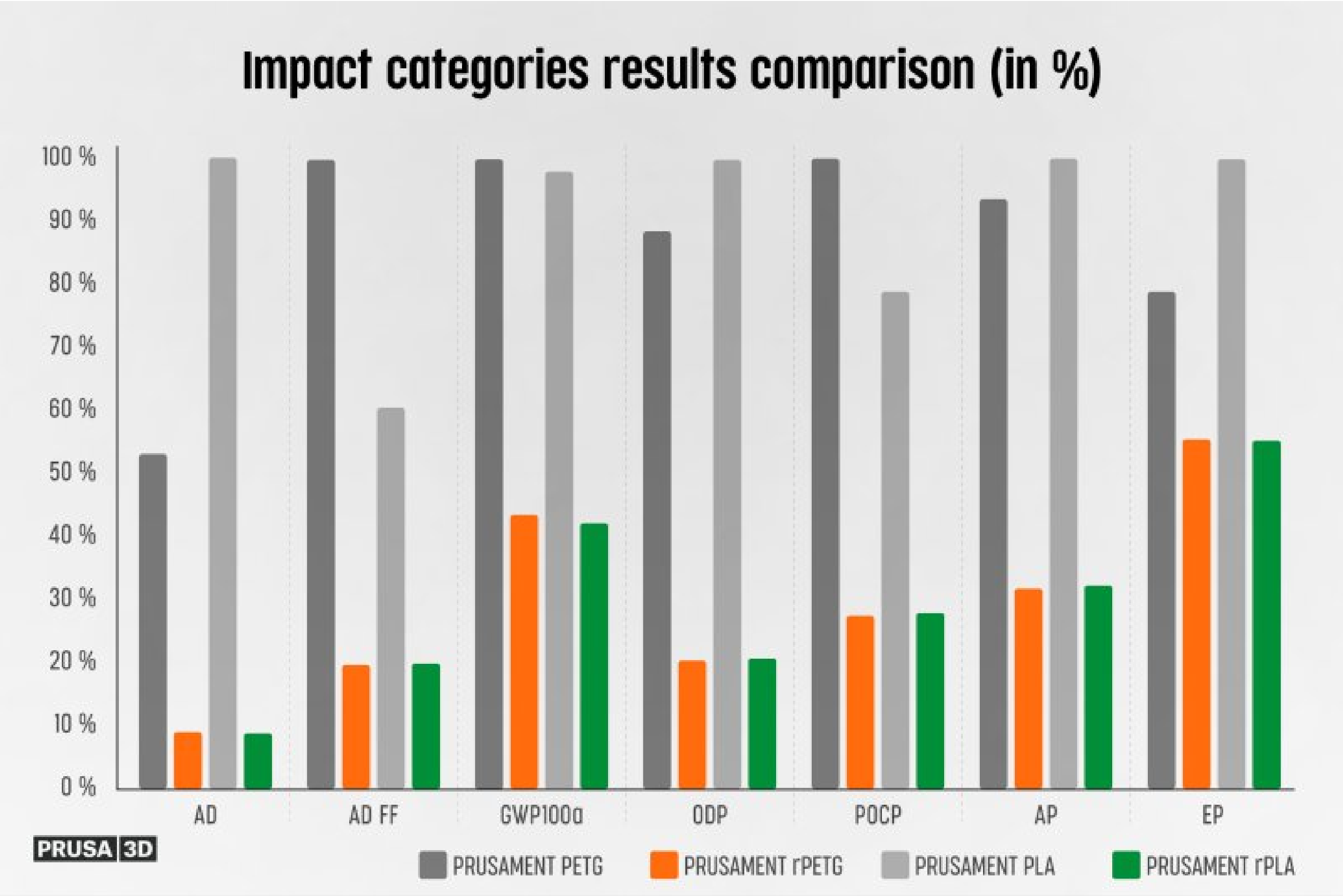
Indicator results for impact categories in the production of 1 kg of Prusament PETG and Prusament PLA vary significantly in selected categories.

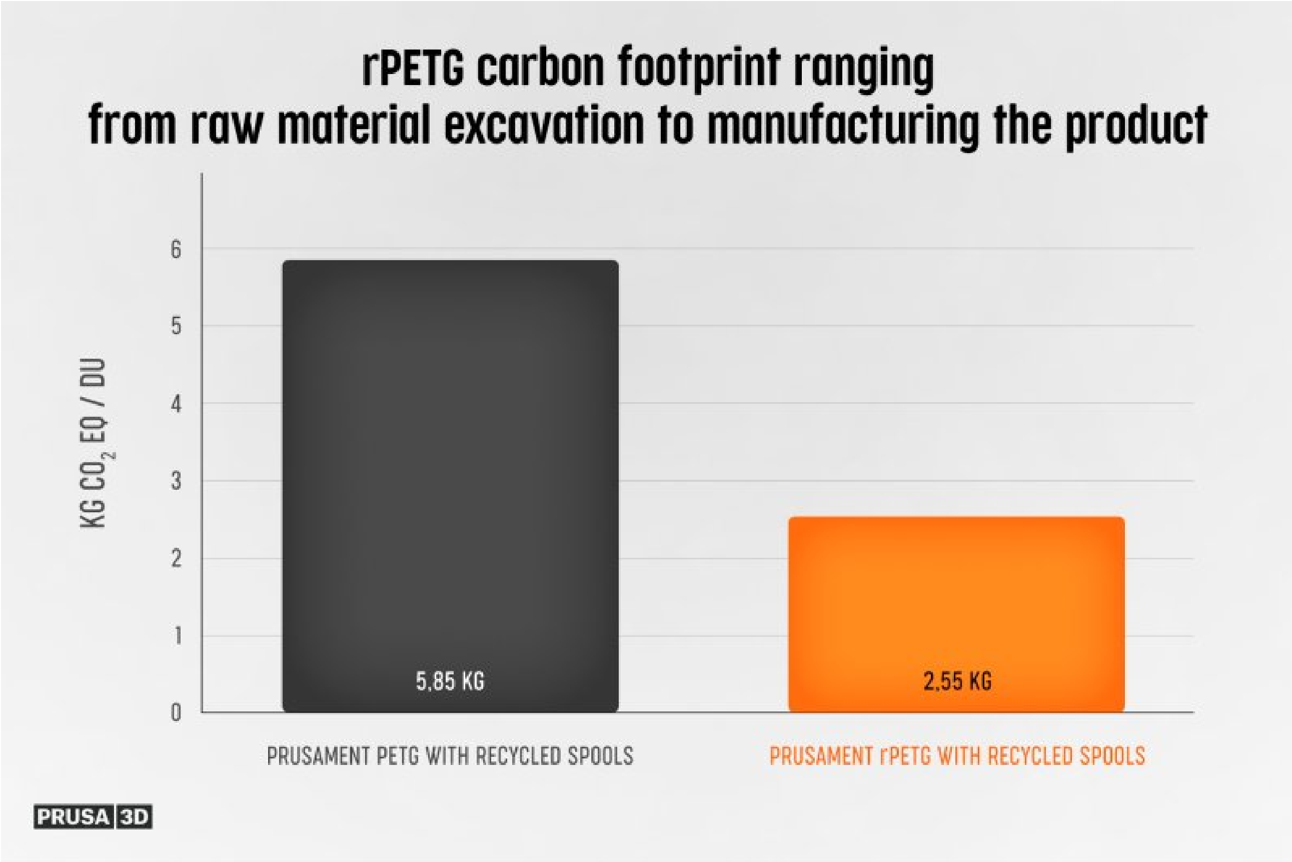


Img. 2 Comparing impact category results for Prusament PETG, PETG Recycled, Prusament PLA and PLA Recycled in %

- **Global warming**

Due to the increasing problems with global warming and its environmental impacts, we have decided to primarily communicate the results of the global warming impact category in CO2 eq emissions, which can also be expressed as the carbon footprint. With these results, we compare the environmental impacts of standard and recycled materials.

The calculated carbon footprint is based on the filament life cycle ranging from raw material excavation to manufacturing of the product.


rPETG carbon footprint ranging
from raw material excavation to manufacturing the product
KG CO_2 EQ / DU
6
5
4
3
2
1
0
5,85 KG
2,55 KG
PRUSAMENT PETG WITH RECYCLED SPOOLS
PRUSAMENT rPETG WITH RECYCLED SPOOLS
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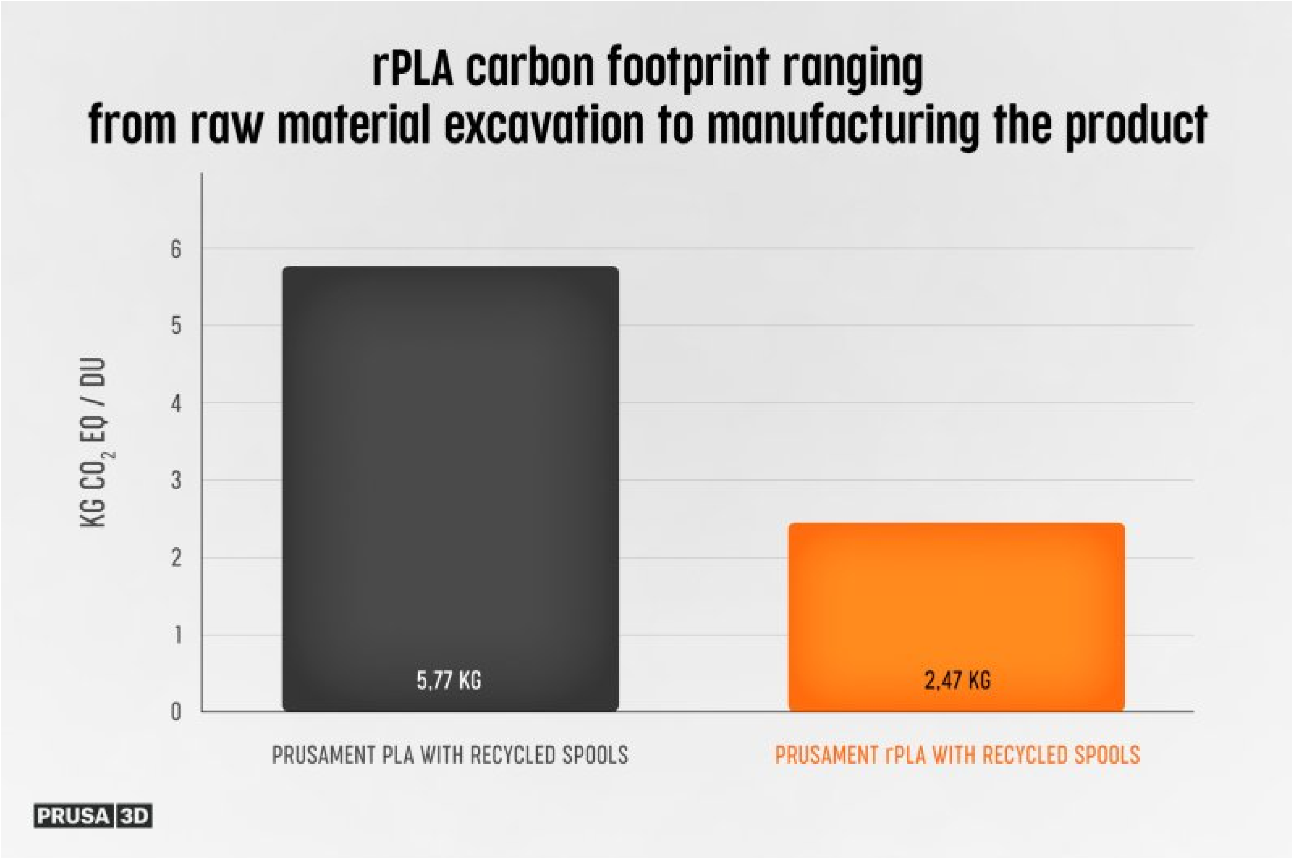
rPLA carbon footprint ranging
from raw material excavation to manufacturing the product
KG CO_2 EQ / DU
6
5
4
3
2
1
0
5,77 KG
2,47 KG
PRUSAMENT PLA WITH RECYCLED SPOOLS
PRUSAMENT rPLA WITH RECYCLED SPOOLS
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4. Conclusions, limitations and recommendations

The results of this inventory analysis and impact assessment clearly state that the recycled filament manufacturing is more environmentally friendly. The reasons are:

- Nearly 60 % less water consumption
- More than 70 % energy savings
- 45-91 % lesser impacts in observed categories, including
- 57 % less greenhouse gases (carbon footprint)

We can clearly recommend the manufacturing of filaments made from waste generated from Prusament PETG and Prusament PLA manufacturing.

**The study was made by Ing. Marie Tichá, a renowned expert in this field of study. She has been working on the LCA since 1993. She is a member of TNK 106 by UNMZ and represented the Czech Republic in international talks ISO/TC 207/SC 5, where she was involved in making ISO 14040 and 14044 (LCA) norms.*