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ENVIRONMENTAL PARAMETERS OF REUSABLE BAGS ROHLIK.CZ

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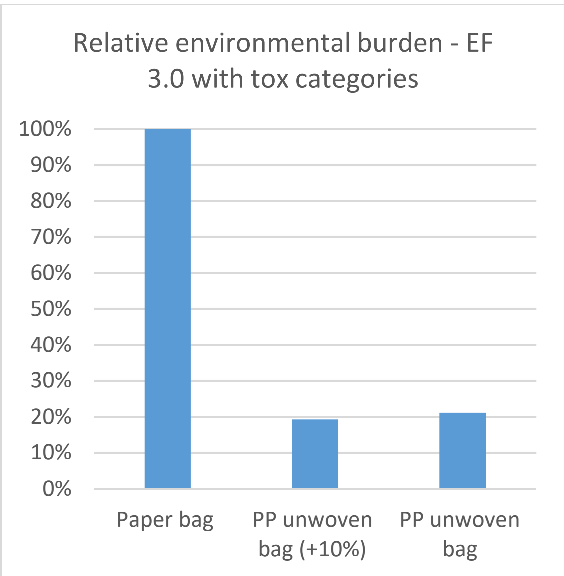
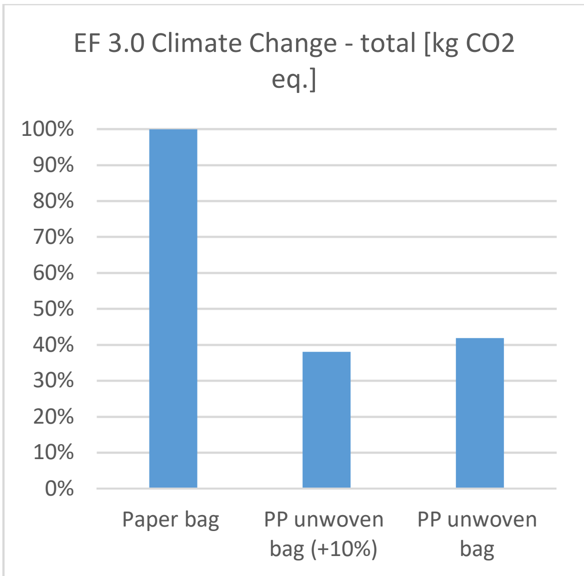
Executive summary

Life cycle assessment conducted based on ISO 14040, and ISO 14044 of paper and polyester non-woven reusable bags are presented in this study. This study aims to compare the potential environmental impacts of paper and rPlastic bags used within the distribution of Rohlik.cz.

Paper bag represents overall higher environmental impacts in compare to reusable plastic bags. The reusable plastic bag made from 98% recycled plastic cause 21% of overall environmental impacts compared to the paper bag. Suppose the plastic bag is used with a 10% higher amount of purchase, then overall environmental impacts of reusable plastic bag drop to 19% of the paper bag. If carbon footprint is used for the comparison, then reusable plastic bag cause only 42% (respectively 38%) of the value of the paper bag.





Content

1 Introduction

This study aims to determine the environmental parameters of reusable cloth bags used in the Rohlik.cz e-shop using the LCA method and compare them with the environmental parameters of the disposable paper bag. The environmental impacts of the evaluated carrier bags were determined by the method of life cycle assessment - LCA (Life Cycle Assessment) following ČSN ISO 14040 and ČSN ISO 14044.

2 Assessed bag description

The commissioner of the study Rohlik.cz provided the data concerning the carrier bags. Data are summarized in the following tables:

Table 1 Characteristics of a non-woven fabric bag

Production	
Producer	China producer
Material	rPet PP unwoven 105 gms
Weight	55g
rPET	Content of secondary PET material was 98 %
Electricity	The production consumes an amount of electricity corresponding to the power input of the sewing machine. For example, the machine's electricity consumption is 250 W, and the sewing time is 20 seconds. This corresponds to the electricity consumption of 1,4 Wh.
Load capacity	10 kg
Washing of textile bag	
Electricity	Electricity consumption: bag 1 Wh/1 bag is used for washing
Natural gas	They use natural gas to heat water, and at the moment, they can't quantify it. So the value of water heat capacity 4180 J · kg^{-1} · K^{-1} and heating from 15 ° C to 60 ° C were used to determine the heat consumption for water heating. Energy losses were not considered.
Water	Water: 0,4 litres per 1 bag for the whole cycle (washing + rinsing)
Detergents	0,25 ml / bag (detergents+desinfection)
Reuse and Disposal	
Repeated use	25
Disposal	Material recyclation

Table 2 Characteristics of a paper bag (Our paper bag)

Producer	„Our paper bag“, production is combined from production plants from Germany, Poland and Slovakia
Composition	Kraftliner, virgin paper 90 gr/m2
Weight	49,8 g
Load capacity	10 kg

Producer	„Our paper bag“, production is combined from production plants from Germany, Poland and Slovakia
Use	1x
Disposal	Sorted Waste management

3 LCA method used and assumptions accepted

3.1 Life Cycle Assessment

The assessment of the bags was performed by the LCA method following ČSN EN ISO 14040 and ČSN EN ISO 14044. In addition, specialized software and databases of inventory data are used for calculations and modelling the life cycles of products or organizations. The professional LCA software GaBi 10 (Sphera solutions). GaBi software developed by the German company Thinkstep in cooperation with the Stuttgart University of Technology was used in this study.

3.1.1 Functional unit

The number of load quantities of 250 kg of purchase was chosen as the functional unit to compare carrier bags. The number was determined based on Rohlík.cz data concerning the average quantity of purchases (10 kg) distributed in a reusable bag.

3.1.2 Reference flow

The reference flow is the number of bags needed to fill the functional unit, i.e., carrying the said quantity of purchase. The amount of bags needed to carry the annual amount of purchase varies depending on each bag's load capacity and life. Therefore, the same bag load capacity (10 kg) were used in the calculations. However, an alternative scenario was also used, where the plastic bag is assumed to have a load capacity 10% higher, i.e. a load capacity of 11 kg.

3.2 Methods of environmental impact assessment

A significant benefit of using the LCA method is the expression of potential environmental impacts by listing various emissions to individual components of the environment and converting these data into results of the so-called impact category indicators. The environmental impact assessment was performed using the PEF 3.0 method, which the European Commission recommends to assess the environmental footprint of products [1]. The following table summarizes the impact categories included in the study.

Table 3 Environmental indicators used, PEF 3.0 methodology

Impact category	**Indicator**	**Unit**	**Method**
Climatic change	Radiative forcing; GWP100	kg CO_2 ekv.	Basic model IPCC 2013 [2]
Stratospheric ozone depletion	ODP	kg CFC11 ekv.	WMO 1999 [3]
Human toxicity cancer effects	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox 2.1. model [4]
Human toxicity non-cancer effects	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox 2.1. model [4]
Particulate matter/Respiratory inorganics	Human health effects associated with exposure to PM2.5	Disease incidences	PM method recommended by UNEP [5]
Ionizing radiation, human health	Human exposure efficiency relative to U^{235}	kBq U^{235}	Human health effect model [6, 7]
Photochemical ozone formation	Tropospheric ozone concentration increase	kg NMVOC eq	LOTOS-EUROS [8]
Acidification	Accumulated Exceedance (AE)	mol H^+ eq	Accumulated exceedance [7]
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N eq	Accumulated exceedance [7]
Eutrophication, aquatic freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P eq	EUTREND model [9]
Eutrophication, aquatic marine	Fraction of nutrients reaching marine end compartment (N)	kg N eq	EUTREND model [9]
Ecotoxicity freshwater	Comparative Toxic Unit for ecosystems (CTUe)	CTUe	USEtox 2.1. model [4]
Land use	Soil quality index (Biotic production, Erosion resistance, Mechanical filtration and groundwater replenishment	Dimensionless, aggregated index of: kg biotic production/(m^2*a) kg soil/(m^2*a) m^3 water/(m^2*a) m^3 g. water/(m^2*a)	Soil quality index based on LANCA [10]
Water use	User deprivation potential (deprivation-weighted water consumption)	kg world eq. deprived	Available WAter REmaining (AWARE) [5]
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb eq	CML [11]
Resource use, energy carriers	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ	CML [11]

3.3 LCA models developed

Based on the input information, the following life cycle models of individually assessed scenarios of carrier bags were created, which was used to calculate environmental indicators.

Against the background of each process shown in the figure, there is a dynamically linked database of environmental impacts, which is used for subsequent calculations of environmental indicators.

Figure 1 Paper bag product system

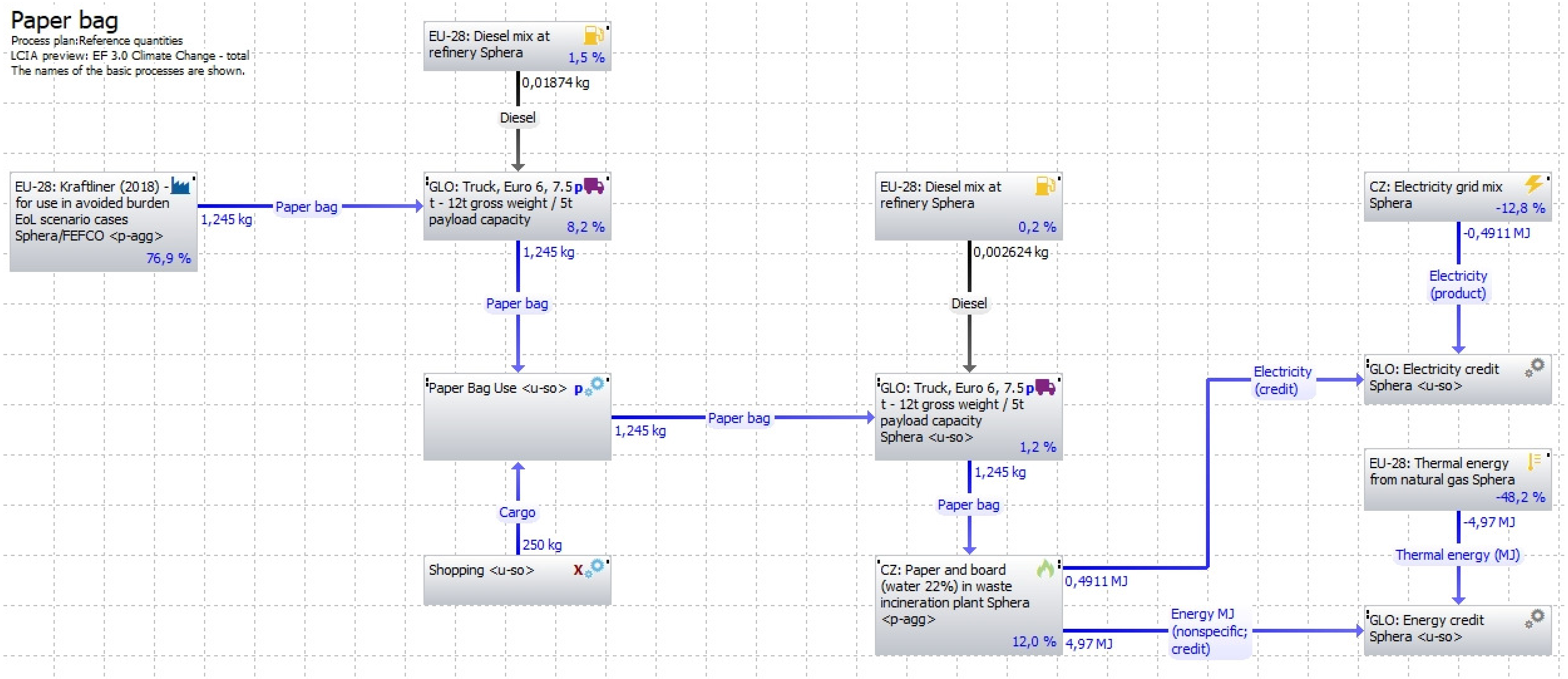


Figure 2 Nonwoven reusable plastic bag product system

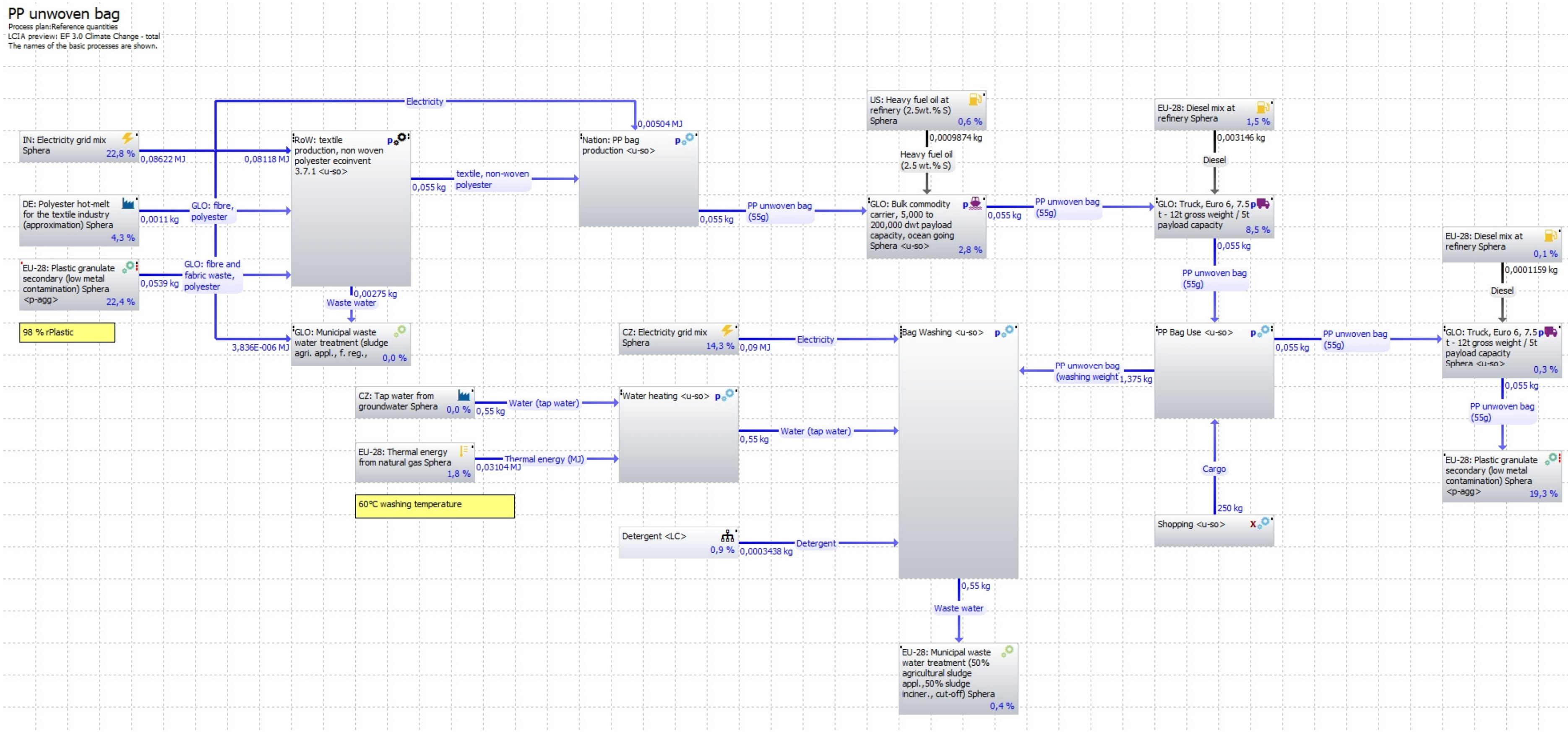
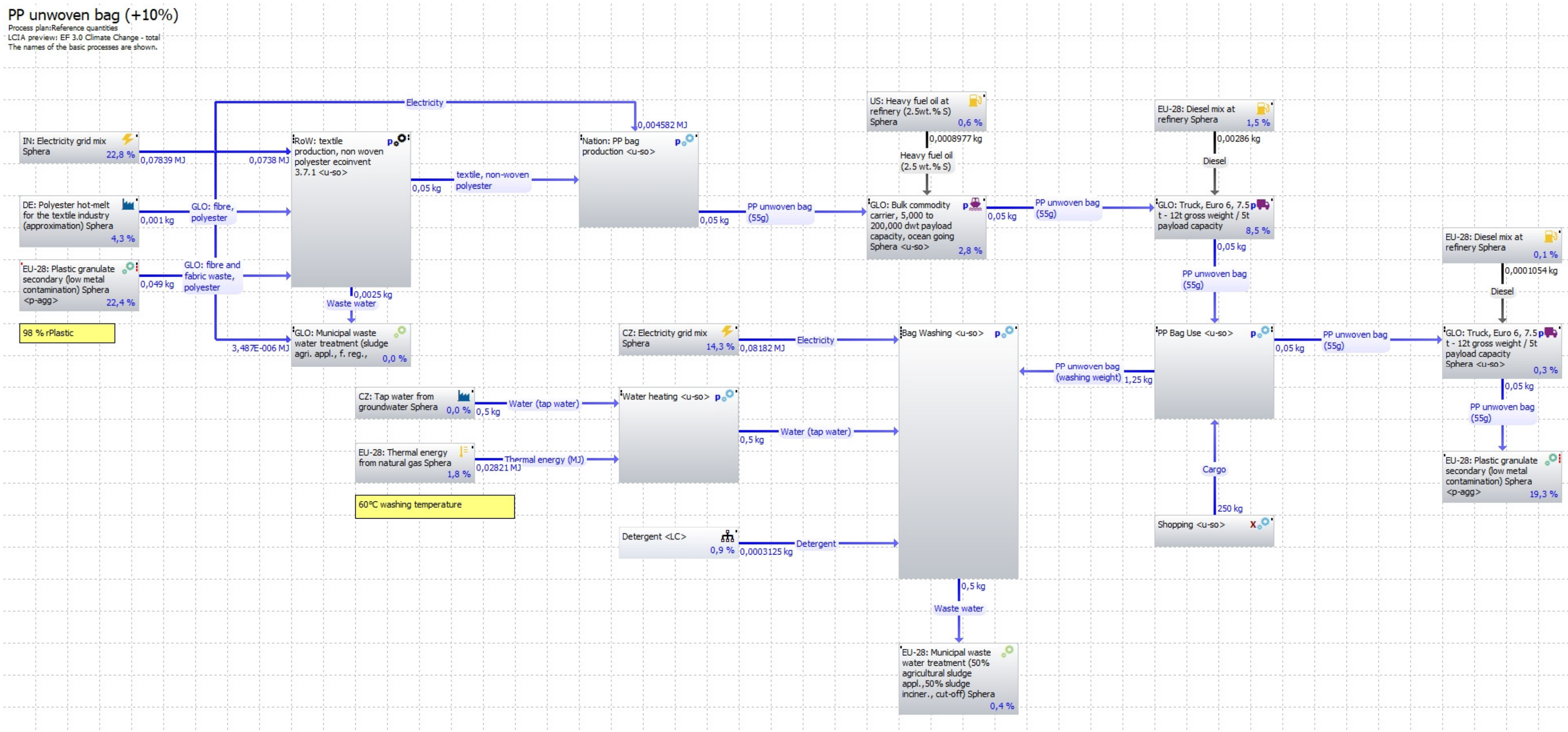


Figure 3 Nonwoven reusable plastic bag with 10% increased carrying capacity product systém


PP unwoven bag (+10%)
Process plan:Reference quantities
LCIA preview: EF 3.0 Climate Change - total
The names of the basic processes are shown.
Electricity
0,004582 MJ
IN: Electricity grid mix Sphera 22,8 %
0,07839 MJ
0,0738 MJ
RoW: textile production, non woven polyester ecoinvent 3.7.1 <u-so>
0,05 kg
textile, non-woven polyester
Nation: PP bag production <u-so>
0,05 kg
PP unwoven bag (55g)
US: Heavy fuel oil at refinery (2.5wt.% S) Sphera 0,6 %
0,0008977 kg
Heavy fuel oil (2.5 wt.% S)
GLO: Bulk commodity carrier, 5,000 to 200,000 dwt payload capacity, ocean going Sphera <u-so> 2,8 %
0,05 kg
PP unwoven bag (55g)
EU-28: Diesel mix at refinery Sphera 1,5 %
0,00286 kg
Diesel
GLO: Truck, Euro 6, 7.5 t - 12t gross weight / 5t payload capacity 8,5 %
0,05 kg
PP unwoven bag (55g)
DE: Polyester hot-melt for the textile industry (approximation) Sphera 4,3 %
0,001 kg
GLO: fibre, polyester
EU-28: Plastic granulate secondary (low metal contamination) Sphera <p-agg> 22,4 %
0,049 kg
GLO: fibre and fabric waste, polyester
0,0025 kg
Waste water
98 % rPlastic
3,487E-006 MJ
GLO: Municipal waste water treatment (sludge agri. appl., f. reg., 0,0 %
CZ: Electricity grid mix Sphera 14,3 %
0,08182 MJ
Electricity
Bag Washing <u-so>
PP unwoven bag (washing weight)
1,25 kg
PP Bag Use <u-so>
0,05 kg
PP unwoven bag (55g)
EU-28: Diesel mix at refinery Sphera 0,1 %
0,0001054 kg
Diesel
GLO: Truck, Euro 6, 7.5 t - 12t gross weight / 5t payload capacity Sphera <u-so> 0,3 %
0,05 kg
PP unwoven bag (55g)
EU-28: Plastic granulate secondary (low metal contamination) Sphera <p-agg> 19,3 %
CZ: Tap water from groundwater Sphera 0,0 %
0,5 kg
Water (tap water)
Water heating <u-so>
0,5 kg
Water (tap water)
EU-28: Thermal energy from natural gas Sphera 1,8 %
0,02821 MJ
Thermal energy (MJ)
60°C washing temperature
Cargo
250 kg
Shopping <u-so>
Detergent <LC> 0,9 %
0,0003125 kg
Detergent
0,5 kg
Waste water
EU-28: Municipal waste water treatment (50% agricultural sludge appl.,50% sludge inciner., cut-off) Sphera 0,4 %

4 Life Cycle Impact Assessment

The following table and graphs show the results of the indicators of individual impact categories of individual bags. The stated values correspond to the selected functional unit - the packaging of a total weight of 250 kg.

Table 4 PEF 3.0 environmental impact indicator results. Results per functional unit expressed – packaging of 250 kg of purchase.

EF 3.0 (Environmental Footprint 3.0)	Paper bag	PP unwoven bag (+10%)	PP unwoven bag
EF 3.0 Acidification [Mole of H+ eq.]	0,003145	0,0005438	0,0005982
EF 3.0 Climate Change - total [kg CO2 eq.]	0,271	0,1031	0,1134
EF 3.0 Climate Change, biogenic [kg CO2 eq.]	0,002037	0,0005069	0,0005576
EF 3.0 Climate Change, fossil [kg CO2 eq.]	0,2671	0,1024	0,1126
EF 3.0 Climate Change, land use and land use change [kg CO2 eq.]	0,001908	2,45E-04	2,70E-04
EF 3.0 Ecotoxicity, freshwater - total [CTUe]	3,931	0,707	0,7777
EF 3.0 Ecotoxicity, freshwater inorganics [CTUe]	3,429	0,3399	0,3738
EF 3.0 Ecotoxicity, freshwater metals [CTUe]	0,456	0,3549	0,3903
EF 3.0 Ecotoxicity, freshwater organics [CTUe]	0,04582	0,01228	0,0135
EF 3.0 Eutrophication, freshwater [kg P eq.]	2,26E-05	1,15E-06	1,27E-06
EF 3.0 Eutrophication, marine [kg N eq.]	0,001342	9,65E-05	1,06E-04
EF 3.0 Eutrophication, terrestrial [Mole of N eq.]	0,01337	0,00103	0,001133
EF 3.0 Human toxicity, cancer - total [CTUh]	1,43E-10	2,06E-11	2,26E-11
EF 3.0 Human toxicity, cancer inorganics [CTUh]	9,47E-20	1,62E-20	1,79E-20
EF 3.0 Human toxicity, cancer metals [CTUh]	7,04E-11	1,30E-11	1,43E-11
EF 3.0 Human toxicity, cancer organics [CTUh]	7,27E-11	7,54E-12	8,30E-12
EF 3.0 Human toxicity, non-cancer - total [CTUh]	8,19E-09	1,26E-09	1,39E-09
EF 3.0 Human toxicity, non-cancer inorganics [CTUh]	4,29E-09	1,96E-10	2,16E-10
EF 3.0 Human toxicity, non-cancer metals [CTUh]	3,87E-09	1,06E-09	1,17E-09

EF 3.0 (Environmental Footprint 3.0)	Paper bag	PP unwoven bag (+10%)	PP unwoven bag
EF 3.0 Human toxicity, non-cancer organics [CTUh]	5,05E-11	9,63E-12	1,06E-11
EF 3.0 Ionising radiation, human health [kBq U235 eq.]	0,05119	0,01217	0,01339
EF 3.0 Land Use [Pt]	253,5	0,3182	0,35
EF 3.0 Ozone depletion [kg CFC-11 eq.]	1,30E-11	1,60E-10	1,76E-10
EF 3.0 Particulate matter [Disease incidences]	4,07E-08	8,11E-09	8,92E-09
EF 3.0 Photochemical ozone formation, human health [kg NMVOC eq.]	0,003585	0,0002742	0,0003016
EF 3.0 Resource use, fossils [MJ]	2,1	1,381	1,519
EF 3.0 Resource use, mineral and metals [kg Sb eq.]	1,87E-07	1,77E-08	1,95E-08
EF 3.0 Water use [m³ world equiv.]	0,2995	-0,009067	-0,009973

The following graph compares the impacts of individual tiles on climate change. Following the International Panel on Climate Change, impacts are expressed in kg CO_2 equivalent.

Figure 4 Carbon footprint of bags assessed. Results per functional unit expressed – packaging of 250 kg of purchase.

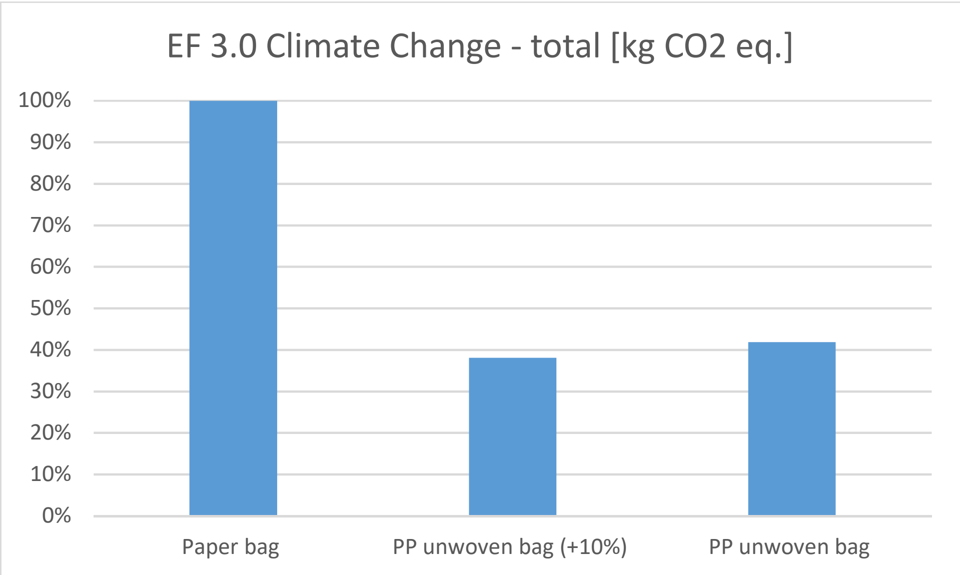


Table 5 Carbon footprint relative comparison of bags assessed

	Paper bag	PP unwoven bag (+10%)	PP unwoven bag
EF 3.0 Climate Change – total [kg CO2 eq.]	100%	38%	42%

The following table and graph show the sums of normalized and weighted results of the indicators of the impact categories of the assessed carrier bags, the overall evaluation using all impact categories of the PEF 3.0 methodology.

Table 6 PEF 3.0 normalized and weighted environmental impact indicator results. Results per functional unit expressed – packaging of 250 kg of purchase.

	Paper bag	PP unwoven bag (+10%)	PP unwoven bag
EF 3.0	0,006151	0,001183	0,001301
EF 3.0 Acidification	0,0003507	6,06E-05	6,67E-05
EF 3.0 Climate Change - total	0,00071	0,0002701	0,0002971
EF 3.0 Ecotoxicity, freshwater - total	1,77E-04	3,18E-05	3,50E-05
EF 3.0 Eutrophication, freshwater	3,93E-05	2,01E-06	2,21E-06
EF 3.0 Eutrophication, marine	2,04E-04	1,47E-05	1,61E-05
EF 3.0 Eutrophication, terrestrial	0,0002803	2,16E-05	2,38E-05
EF 3.0 Human toxicity, cancer - total	1,64E-05	2,36E-06	2,59E-06
EF 3.0 Human toxicity, non-cancer - total	6,55E-05	1,01E-05	1,11E-05
EF 3.0 Ionising radiation, human health	0,001859	0,0004418	0,000486
EF 3.0 Land Use	0,0009025	1,13E-06	1,25E-06
EF 3.0 Ozone depletion	1,70E-09	2,08E-08	2,29E-08
EF 3.0 Particulate matter	0,0006129	1,22E-04	1,34E-04
EF 3.0 Photochemical ozone formation, human health	0,0004211	3,22E-05	3,54E-05
EF 3.0 Resource use, fossils	0,0002688	0,0001768	1,95E-04
EF 3.0 Resource use, mineral and metals	2,22E-05	2,11E-06	2,32E-06
EF 3.0 Water use	2,22E-04	-6,71E-06	-7,38E-06

Figure 5 Sum of normalized and weighted results of impact category indicators. Results per functional unit expressed – packaging of 250 kg of purchase.

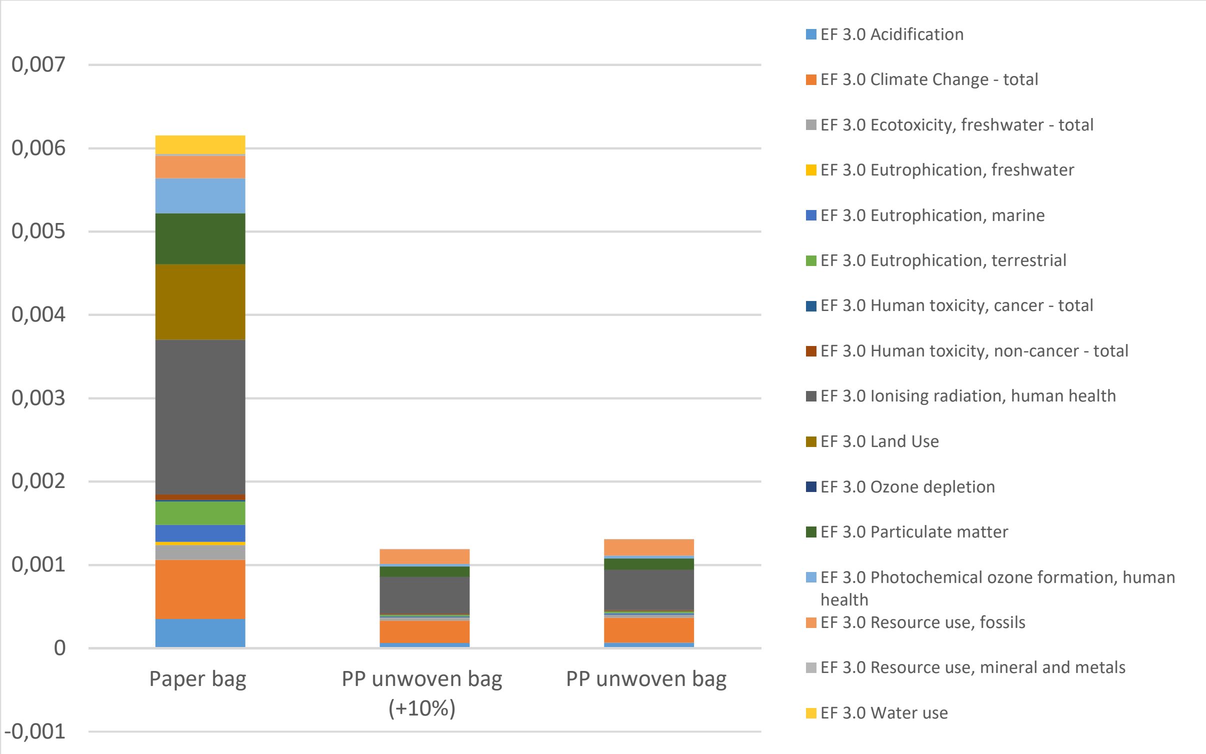


Table 7 Overall comparison of the sum of normalized and weighted results of impact category indicators

	Paper bag	**PP unwoven bag (+10%)**	**PP unwoven bag**
Relative environmental burden - EF 3.0 with tox categories	100%	19%	21%

5 Conclusions

In the study, the life cycle assessment method (LCA, ČSN ISO 14040) was used to evaluate the environmental impacts of the life cycle of carrier bags considered for use in Rohlik.cz. Paper bag represents overall higher environmental impacts in compare to reusable plastic bags. The reusable plastic bag made from 98% recycled plastic cause 21% of overall environmental impacts compared to paper bags. Suppose the plastic bag is used with a 10% higher purchase Overall, the environmental impacts of reusable plastic bags drop to 19% of the paper bag. If carbon footprint is used for the comparison, then reusable plastic bag cause only 42% (respectively 38%) of the paper bag.

The significant findings formulated based on the inventory and life cycle impact assessment results are the following: **Reusable plastic bag made of recycled plastic has lower environmental impacts than a disposable paper bag.**

6 Literature

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