INSTITUT FÜR ENERGIE- UND UMWELTFORSCHUNG HEIDELBERG

SIGNATURE **portfolio**

Extension: Analysis of combibloc **ECO**PLUS & **SIG**NATURE 100 and **SIG**NATURE FULL BARRIER for combiblocSlimline and combiblocMidi on the Dutch market

Comparative life cycle assessment of beverage cartons containing polymers based on the mass-balanced renewable material approach

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1 Introduction

The focus of the main report is to investigate combiblocSlimline (cb3) and combiblocMidi (cb8) cartons on the European market. In this extension, the beverage cartons listed in **Table 1-1**, which were already examined in the main report, are evaluated again with country-specific parameters for the Netherlands (same material composition, same weight). The comparisons of the beverage cartons are structured according to the same scheme.

As the SIG packaging combifitMidi (cf8) is identical to the combiblocMidi (cb8) with regard to all packaging specifications (including secondary and tertiary packaging), the results of the combiblocMidi (cb8) 1000 mL also apply to the combifitMidi (cf8) 1000 mL.

The following abbreviations, which are included in the packaging names are applied in this study:

- combiblocSlimline (cb3)
- combiblocMidi (cb8)
- Standard RS (robust structure)
- cSwift (combiSwift)
- cMaxx (combiMaxx)
- **SIG**NATURE PACK FB (full barrier, containing aluminium)
- **SIG**NATURE PACK 100 (100% mass-balanced PE, PP, PA)

Table 1-1: List of beverage cartons examined in the Netherlands (1000 mL)

combiblocSlimline (cb3) beverage cartons and closure	**combiblocMidi (cb8) beverage cartons and closure**
cb3 standard RS (cSwift)	cb8 standard RS (cSwift)
cb3 standard RS (cMaxx)	cb8 standard RS (cMaxx)
cb3 EcoPlus (cSwift LP)	cb8 EcoPlus (cSwift LP)
cb3 **SIG**NATURE PACK 100 (cSwift LP)	cb8 **SIG**NATURE PACK 100 (cSwift LP)
cb3 **SIG**NATURE PACK FB (cSwift)	cb8 **SIG**NATURE PACK FB (cSwift)
cb3 **SIG**NATURE PACK FB (cMaxx)	cb8 **SIG**NATURE PACK FB (cMaxx)

This extension focusses only on one environmental impact category, ‘Climate Change’. Impacts on ‘Climate Change’ depend strongly on local settings like end-of-life processes or the local electricity mix. For other environmental impact categories, please refer to the results regarding the European market that are presented in the main report.

The following parameters correspond to the parameters of the main report on the European market:

- Functional unit
- System boundaries
- Data gathering and data quality
- Methodological aspects (mass-balanced renewable material approach, allocation, biogenic carbon)
- Manufacture of raw materials
- Process data for converting and filling
- Electricity mix for converting processes

Adjusted parameters for the geographic scope of the extension are:

- Distribution
- End-of-life
- Electricity mix for filling processes, recycling processes and credits
- Electrical and thermal efficiencies of the municipal waste incineration
- Landfill gas recovery rates

2 Adjusted parameters

2.1 Distribution

Table 2-1 shows the applied distribution distances in this extension. The distribution distances for the Dutch market from filling to POS were provided by SIG Combibloc.

Table 2-1: Distribution distances in The Netherlands for the examined packaging systems

	Distribution distance			
	Distribution Step 1		**Distribution step 2**	
Market	**Filler → distribution centre** (delivery)	**Distribution centre → filler** (return trip)	**Distribution centre → POS** (delivery)	**POS → distribution centre** (return trip)
The Netherlands	200 km	60 km	30 km	30 km

2.2 End-of-life

To model the end-of-life of the examined beverage cartons one needs to know their fate after their use by the consumers. It is aimed to apply the recycling rate and disposal split for the beverage cartons of the Dutch market. These data has been collected from different waste management reports and statistics. For beverage cartons specific recycling rates are publicly available for the market examined.

The applied recycling rate and the disposal split for The Netherlands are listed in **Table 2-2**.

Table 2-2: End-of-life split of beverage cartons examined

The Netherlands		Source
Recycling rate		
Beverage cartons	confidential	(EXTR:ACT 2020)
Disposal split		
Landfill	3.3%	(Eurostat 2021) municipal waste statistic, data for 2019
Incineration	96.7%	

2.3 Electricity mix

Modelling of electricity generation is particularly relevant for the production of base materials as well as for filling processes, recycling processes and credits. Electric power supply is modelled using country specific grid electricity mixes, since the environmental burdens of power production varies strongly depending on the electricity generation technology. A more detailed description is given in **section 3.9.2** of the main report.

The emission factor (Climate Change) for The Netherlands is 510 g/kWh for the electricity mix used (reference year 2018) (Fehrenbach et al. 2016; IEA 2018), while the average EU electricity mix is 416 g/kWh. This means that the Dutch electricity mix is responsible for around 18% higher greenhouse gas emissions than the European one.

2.4 Municipal waste incineration

The electrical and thermal efficiencies of the municipal solid waste incineration plants (MSWI) are shown in table **Table 2-3**.

Table 2-3: Electrical and thermal efficiencies of the incineration plants for The Netherlands

Geographic Scope	Electrical efficiency	Thermal efficiency	Reference period	Source
The Netherlands	16.0%	8.0%	2010	(CEWEP 2012)

The efficiencies are used as parameters for the incineration model, which assumes a technical standard (especially regarding flue gas cleaning) that complies with the requirements given by the EU incineration directive (EU 2018). It is assumed that the electric energy generated in MSWI plants substitutes market specific grid electricity. Furthermore, it is assumed that the thermal energy recovered in MSWI plants is used as process heat.

3 Results and discussion

3.1 The Netherlands combiblocSlimline (cb3) beverage cartons 1000 mL

3.1.1 Scenario I (50% allocation): numerical values and graphs

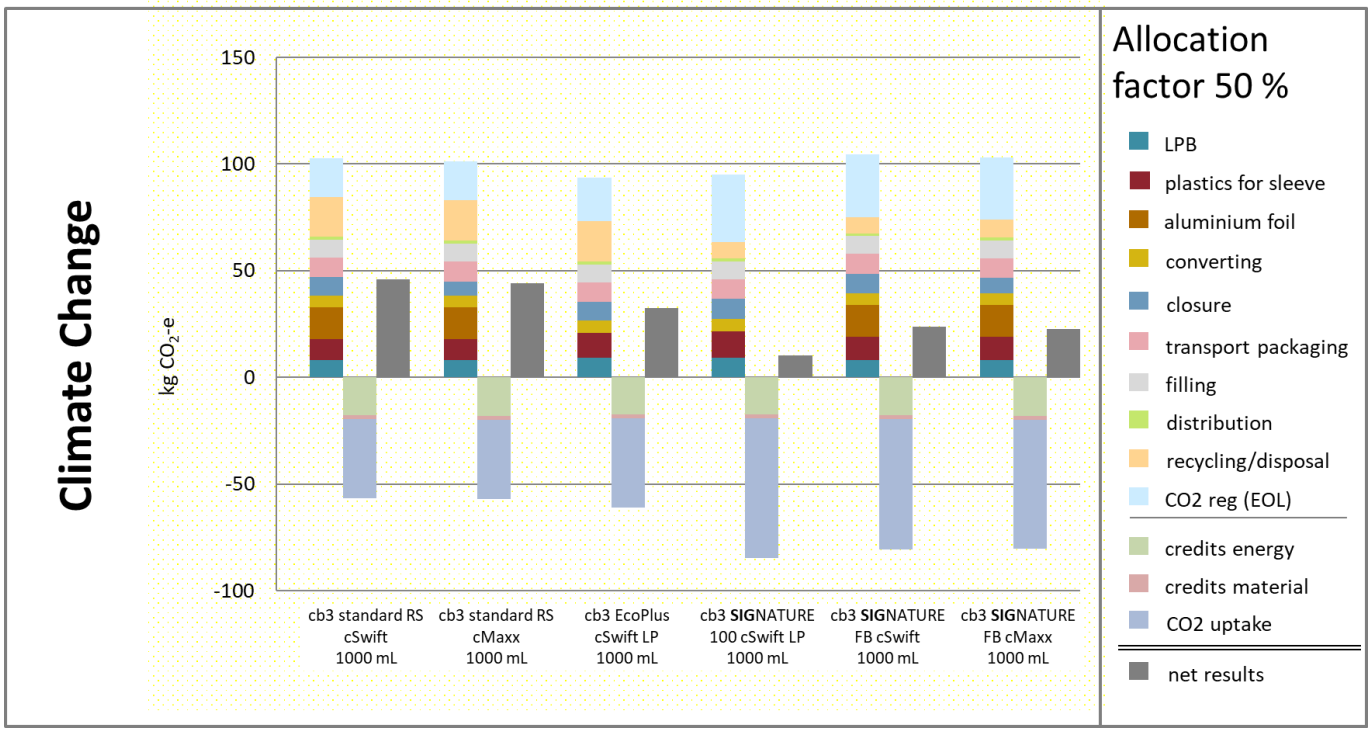

Figure 3-1: Climate Change results of **scenario I The Netherlands, combiblocSlimline (cb3) beverage cartons** with allocation factor 50%

Table 3-1: Climate Change results of **scenario I The Netherlands, combiblocSlimline (cb3) beverage cartons** with allocation factor 50%: burdens, credits and net results per functional unit of 1000 L beverage

Scenario I Netherlands, allocation factor 50 %		cb3 standard RS cSwift 1000 mL	cb3 standard RS cMaxx 1000 mL	cb3 EcoPlus cSwift LP 1000 mL	cb3 SIGNATURE 100 cSwift LP 1000 mL	cb3 SIGNATURE FB cSwift 1000 mL	cb3 SIGNATURE FB cMaxx 1000 mL
Climate Change [kg CO_2-equivalents]	Burdens	84.64	83.18	73.05	63.40	74.91	73.75
	CO_2 (reg)	18.13	18.13	20.40	31.55	29.54	29.17
	Credits	-19.67	-19.91	-19.30	-19.30	-19.67	-19.91
	CO_2 uptake	-37.19	-37.20	-41.87	-65.27	-61.13	-60.32
	Net results (∑)	45.90	44.20	32.27	10.37	23.65	22.69

3.1.2 Scenario II (100% allocation): numerical values and graphs

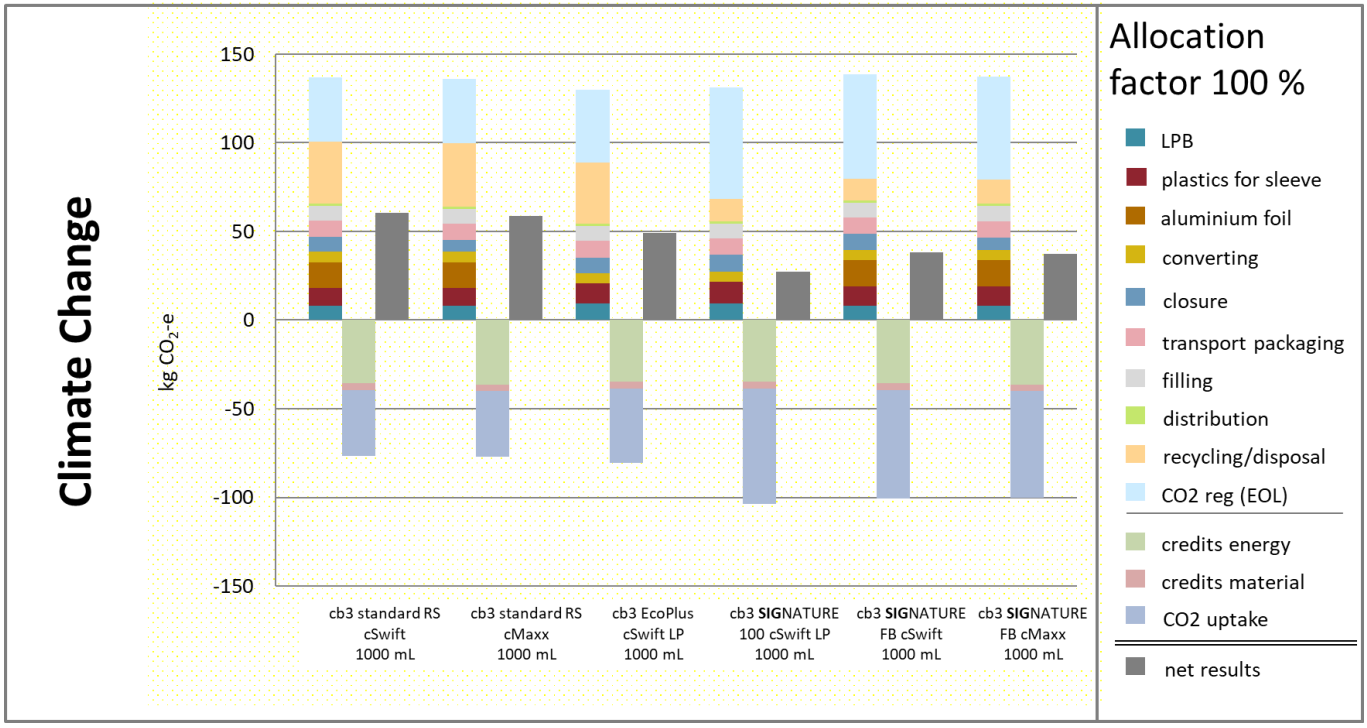

Figure 3-2: Climate Change results of **scenario II The Netherlands, combiblocSlimline (cb3) beverage cartons** with allocation factor 100%

Table 3-2: Climate Change results of **scenario II The Netherlands, combiblocSlimline (cb3) beverage cartons** with allocation factor 100%: burdens, credits and net results per functional unit of 1000 L beverage

Scenario II Netherlands, allocation factor 100 %		cb3 standard RS cSwift 1000 mL	cb3 standard RS cMaxx 1000 mL	cb3 EcoPlus cSwift LP 1000 mL	cb3 SIGNATURE 100 cSwift LP 1000 mL	cb3 SIGNATURE FB cSwift 1000 mL	cb3 SIGNATURE FB cMaxx 1000 mL
Climate Change [kg CO_2-equivalents]	Burdens	100.77	99.74	89.04	68.23	79.62	79.27
	CO_2 (reg)	36.12	36.13	40.65	62.95	58.95	58.20
	Credits	-39.34	-39.81	-38.60	-38.60	-39.34	-39.81
	CO_2 uptake	-37.19	-37.20	-41.87	-65.27	-61.13	-60.32
	Net results (∑)	60.36	58.86	49.22	27.32	38.10	37.34

3.1.3 Comparison between systems

The percentages in **Table 3-3** show the difference of net results between all considered formats of combiblocSlimline (cb3) beverage cartons in the same volume segment. The percentage is based on the net results of each compared packaging system. Both scenarios, scenario I (AF 50) and scenario II (AF 100), are equally used for the comparison between the systems. Differences of 10% or less are considered to be insignificant.

Table 3-3: Comparison of Climate Change net results of **combiblocSlimline (cb3) beverage cartons** (The Netherlands)

	The net results of									
	combibloc-Slimline (cb3) EcoPlus cSwift LP 1000 mL		**combiblocSlimline (cb3) SIGNATURE 100 cSwift LP 1000 mL**				**combibloc-Slimline (cb3) SIGNATURE FB cSwift 1000 mL**		**combibloc-Slimline (cb3) SIGNATURE FB cMaxx 1000 mL**	
	are lower (green)/higher (red) than those of									
	combibloc-Slimline (cb3) standard RS cSwift 1000 mL		combibloc-Slimline (cb3) standard RS cSwift 1000 mL		combibloc-Slimline (cb3) EcoPlus cSwift LP 1000 mL		combibloc-Slimline (cb3) standard RS cSwift 1000 mL		combibloc-Slimline (cb3) standard RS cMaxx 1000 mL	
	AF 50	**AF 100**	**AF 50**	**AF 100**	**AF 50**	**AF 100**	**AF 50**	**AF 100**	**AF 50**	**AF 100**
Impact category										
Climate Change	-30%	-18%	-77%	-55%	-68%	-44%	-48%	-37%	-49%	-37%

The combiblocSlimline (cb3) EcoPlus cSwift LP shows lower net results in the 'Climate Change' category than the compared combiblocSlimline (cb3) standard RS cSwift. All the **SIG**NATURE beverage cartons show lower net results in the 'Climate Change' category than the standard and EcoPlus cartons compared in both scenario variants (AF 50, AF 100).

For this category and the comparison of combiblocSlimline (cb3) packaging systems, the results for The Netherlands show a similar picture as those of the European market.

3.2 The Netherlands combiblocMidi (cb8) beverage cartons 1000 mL

3.2.1 Scenario I (50% allocation): Numerical values and graphs

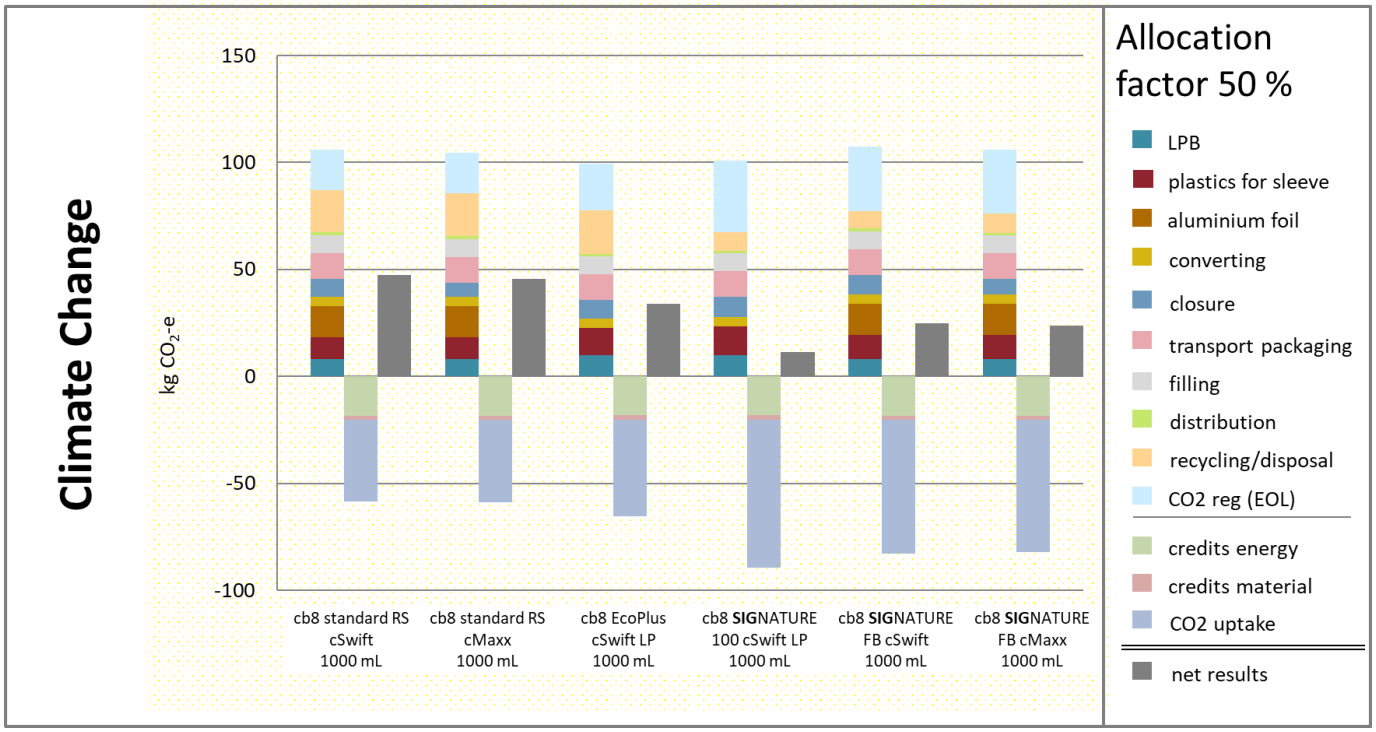

Figure 3-3: Climate Change results of **scenario I The Netherlands, combiblocMidi (cb8) beverage cartons** with allocation factor 50%

Table 3-4: Climate Change results of **scenario I The Netherlands, combiblocMidi (cb8) beverage cartons** with allocation factor 50%: burdens, credits and net results per functional unit of 1000 L beverage

Scenario I Netherlands, allocation factor 50 %		cb8 standard RS cSwift 1000 mL	cb8 standard RS cMaxx 1000 mL	cb8 EcoPlus cSwift LP 1000 mL	cb8 SIGNATURE 100 cSwift LP 1000 mL	cb8 SIGNATURE FB cSwift 1000 mL	cb8 SIGNATURE FB cMaxx 1000 mL
Climate Change [kg CO_2-equivalents]	Burdens	87.07	85.62	77.40	67.44	77.22	76.06
	CO_2 (reg)	18.70	18.70	21.91	33.37	30.27	29.89
	Credits	-20.13	-20.37	-20.31	-20.31	-20.13	-20.37
	CO_2 uptake	-38.36	-38.37	-44.97	-69.01	-62.61	-61.81
	Net results (∑)	47.28	45.58	34.03	11.49	24.73	23.77

3.2.2 Scenario II (100% allocation): Numerical values and graphs

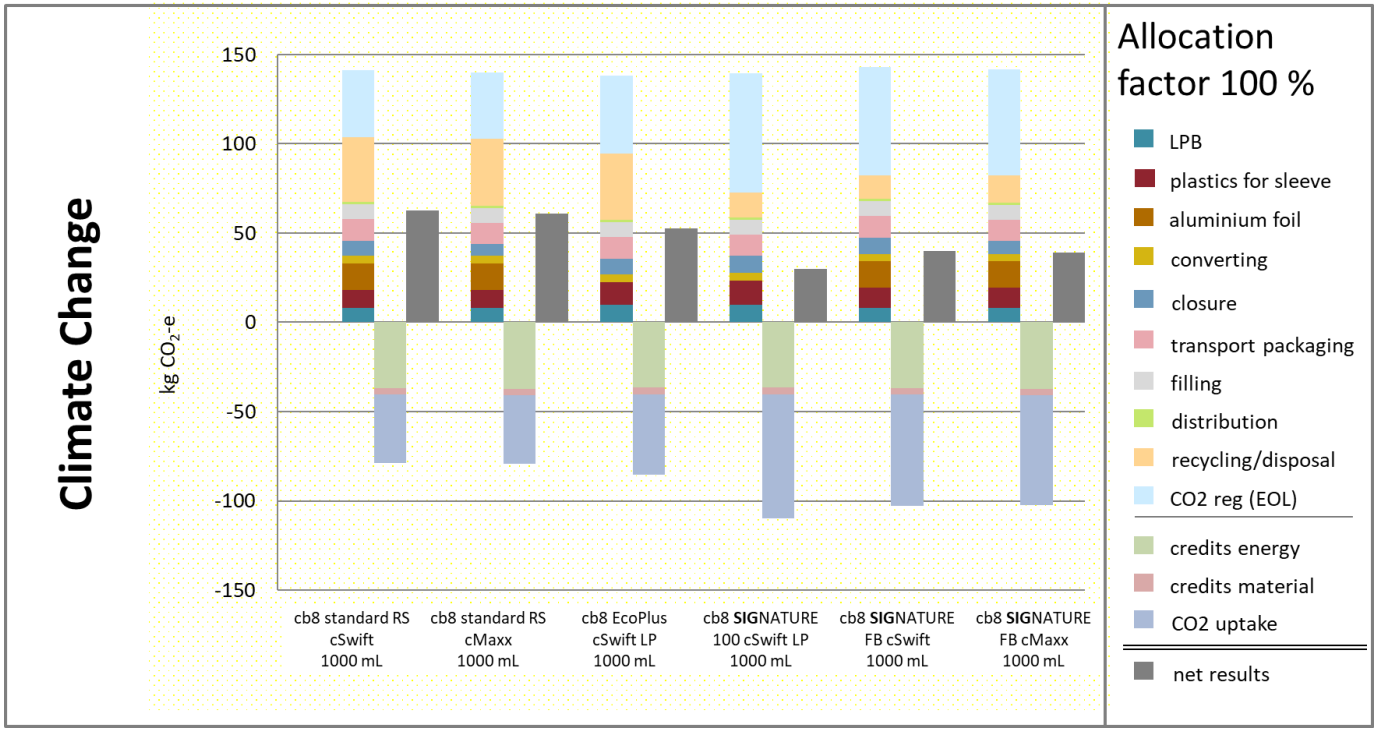

Figure 3-4: Climate Change results of **scenario II The Netherlands, combiblocMidi (cb8) beverage cartons** with allocation factor 100%

Table 3-5: Climate Change results of **scenario II The Netherlands, combiblocMidi (cb8) beverage cartons** with allocation factor 100%: burdens, credits and net results per functional unit of 1000 L beverage

Scenario II Netherlands, allocation factor 100 %		cb8 standard RS cSwift 1000 mL	cb8 standard RS cMaxx 1000 mL	cb8 EcoPlus cSwift LP 1000 mL	cb8 SIGNATURE 100 cSwift LP 1000 mL	cb8 SIGNATURE FB cSwift 1000 mL	cb8 SIGNATURE FB cMaxx 1000 mL
Climate Change [kg CO_2-equivalents]	Burdens	103.87	102.85	94.32	72.89	82.44	82.09
	CO_2 (reg)	37.26	37.27	43.66	66.57	60.40	59.64
	Credits	-40.26	-40.73	-40.60	-40.60	-40.26	-40.73
	CO_2 uptake	-38.36	-38.37	-44.97	-69.01	-62.61	-61.81
	Net results (∑)	62.51	61.02	52.40	29.85	39.96	39.20

3.2.3 Comparison between systems

The percentages in **Table 3-6** show the difference of net results between all considered formats of combiblocMidi (cb8) beverage cartons in the same volume segment. The percentage is based on the net results of each compared packaging system. Both scenarios, scenario I (AF 50) and scenario II (AF 100), are equally used for the comparison between the systems. Differences of 10% or less are considered to be insignificant.

Table 3-6: Comparison of Climate Change net results of **combiblocMidi (cb8) beverage cartons** (The Netherlands)

	The net results of									
	combiblocMidi (cb8) EcoPlus cSwift LP 1000 mL		**combiblocMidi (cb8) SIGNATURE 100 cSwift LP 1000 mL**				**combiblocMidi (cb8) SIGNATURE FB cSwift 1000 mL**		**combiblocMidi (cb8) SIGNATURE FB cMaxx 1000 mL**	
	are lower (green)/higher (red) than those of									
	combiblocMidi (cb8) standard RS cSwift 1000 mL		combiblocMidi (cb8) standard RS cSwift 1000 mL		combiblocMidi (cb8) EcoPlus cSwift LP 1000 mL		combiblocMidi (cb8) standard RS cSwift 1000 mL		combiblocMidi (cb8) standard RS cMaxx 1000 mL	
	AF 50	**AF 100**	**AF 50**	**AF 100**	**AF 50**	**AF 100**	**AF 50**	**AF 100**	**AF 50**	**AF 100**
Impact category										
Climate Change	-28%	-16%	-76%	-52%	-66%	-43%	-48%	-36%	-48%	-36%

The combiblocMidi (cb8) EcoPlus cSwift LP shows lower net results in the 'Climate Change' category than the compared combiblocMidi (cb8) standard RS cSwift. All the **SIG**NATURE beverage cartons show lower net results in the 'Climate Change' category than the standard and EcoPlus cartons compared in both scenario variants (AF 50, AF 100).

For this category and the comparison of combiblocMidi (cb8) packaging systems, the results for The Netherlands show a similar picture as those of the European market.

4 Conclusions and Recommendations

Conclusions

- The combiblocSlimline (cb3) EcoPlus cSwift LP shows lower net results in the 'Climate Change' category than the compared combiblocSlimline (cb3) standard RS cSwift. All the **SIG**NATURE beverage cartons show lower net results in the 'Climate Change' category than the standard and EcoPlus cartons compared in both scenario variants (AF 50, AF 100). For this category and the comparison of combiblocSlimline (cb3) packaging systems, the results for The Netherlands show a similar picture as those of the European market.
- The combiblocMidi (cb8) EcoPlus cSwift LP shows lower net results in the 'Climate Change' category than the compared combiblocMidi (cb8) standard RS cSwift. All the **SIG**NATURE beverage cartons show lower net results in the 'Climate Change' category than the standard and EcoPlus cartons compared in both scenario variants (AF 50, AF 100). For this category and the comparison of combiblocMidi (cb8) packaging systems, the results for The Netherlands show a similar picture as those of the European market.
- To get an indication of how the packaging systems examined in this extension study perform in other environmental impact categories like 'Ozone Depletion', 'Summer Smog', 'Particulate Matter', 'Acidifi-cation', 'Terrestrial- and Aquatic Eutrophication', 'Abiotic Resource Depletion', 'Non-renewable Primary Energy' and 'Total Primary Energy', one can also refer to the main report regarding the European market. However, some background parameters are different due to the different geographical scopes. For this reason, the results of the European scope can only serve as an indication of the full set of environmental impact categories.

Recommendations

- Since the environmental result of the combiblocSlimline (cb3) and combiblocMidi (cb8) beverage carton format is significantly influenced by the production of its main components, the sleeve and closure, measures to ensure the same functionality by the use of less material are recommended.
- It is shown in this study that the closures play a crucial role in the life cycle of the combiblocSlimline (cb3) and combiblocMidi (cb8) beverage carton formats. To improve the overall environmental performance, it is recommended to assess the possibilities of using smaller and lighter closures for all combiblocSlimline (cb3) and combiblocMidi (cb8) beverage carton formats.
- The beverage cartons combiblocSlimline (cb3) and combiblocMidi (cb8) **SIG**NATURE 100 with the closure cSwift LP (1000 mL) show the lowest environmental impacts in 'Climate Change'. Therefore, from an environmental viewpoint it is recommended to prefer the combiblocSlimline (cb3) and combiblocMidi (cb8) **SIG**NATURE 100 cSwift LP (1000 mL) over the other beverage carton formats examined in this study on the Dutch market.
- By comparing the closure results of the examined combiblocSlimline (cb3) and combiblocMidi (cb8) **SIG**NATURE FB cSwift (1000 mL) with the combiblocSlimline (cb3) and combiblocMidi (cb8) standard RS cSwift on the Dutch market, it can be concluded, that the substitution of fossil polymers by mass-balanced polymers based on tall oil leads to lower net results in 'Climate Change'. The implementation of polymers based on tall oil via a mass-balance approach therefore is recommended.
- It is also recommended to actually achieve a more significant physical share of tall oil based input materials for the production of polymers, as the by-product of the pulp industry is currently only dedicated to direct thermal use. The utilisation and demand of mass-balanced polymers by SIG Combibloc might be a driver to do so.

References

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