Life Cycle Assessment of Aluminium Beverage Cans in Europe

EXECUTIVE SUMMARY - July 2019

Metal Packaging Europe (MPE) is the European federation of metal packaging makers, bringing together over 300 manufacturers, suppliers and their national associations to promote the benefits of rigid metal packaging, an industry which employs over 60,000 people in 23 European countries.

With growing demand for sustainable production and consumption, MPE is fully committed to providing objective and reliable information about the environmental performance of rigid metal packaging, given its critical role within the circular economy. This informed MPE's decision to commission RDC Environment to conduct an in-depth Life Cycle Assessment (LCA) according to the requirements of the international standard ISO 14040/44, determining the average environmental performance of aluminium beverage cans (25, 33 and 50 cl) produced in Europe in 2016.

The study covers the life cycle of aluminium beverage cans (see Figure 1) from raw materials extraction to cans' manufacturing (so-called "cradle-to-gate"), transport to fillers, and recycling and disposal routes of the cans after being used (so-called "End-of-Life"); some phases of the life cycle (such as the filling and the use of cans) are excluded from the study as they are not under the direct control of MPE members.

Production data was collected from 26 manufacturing plants across Europe (see Figure 2) and, based on the available market information provided by MPE members and GlobalData, this LCA study covers 87% of the aluminium beverage cans manufactured in Europe.

The LCA study clearly demonstrates the positive environmental contribution of recycling aluminium beverage cans: they are endlessly recyclable without substantial loss of quality, which allows to significantly reduce virgin aluminium production. The study evaluated the environmental effects of technical improvements wrought over the last 10 years (from 2006 to 2016) in relation to aluminium production, can manufacturing and recycling rate.

The findings were impressive: there was an average reduction of 31% in CO_2-equivalent emissions across all three beverage can volumes. This confirms the industry's commitment to reducing carbon

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emissions and decoupling production growth from its environmental footprint.

The environmental performance of aluminium beverage cans is expressed according to the functional unit which is defined as: one thousand (1,000) units of aluminium beverage cans used to contain, protect and decorate standard volumes of beverages (25, 33 and 50 cl). The average weight of the cans is indicated in Table 1.

Weight	Unit	25 cl	33 cl	50 cl
Body + bottom end	g	7.9	9.8	12.8
Top end	g	2.5	2.4	2.4
Can	g	10.4	12.2	15.1

Table 1 Average weight of the aluminium beverage cans assessed in this study

The environmental performance of aluminium beverage cans is extensively described in the study by 14 impact categories (see Table 8), among which the most relevant for the metal packaging industry focus on: the effect on climate change of greenhouse gases emissions and the effect on the environment of fossil mineral resource and water depletions. The results for the most relevant impact categories are indicated in Table 2 whereas the complete list of results is reported in Table 6.

Impact category	Unit	25 cl	33 cl	50 cl
Climate change	kg CO_2 eq.	62.27	77.21	106.09
Abiotic resource depletion	kg Sb eq.	2.51E-03	3.01E-03	4.05E-03
Water scarcity	m^3 water eq.	7.61	10.13	12.43

Table 2 Environmental performance of 1,000 units of aluminium beverage cans according to the most relevant impact categories

By dividing per 1000 the figures in Table 2, the results are expressed per one aluminium beverage can in Table 3.

Impact category	Unit	25 cl	33 cl	50 cl
Climate change	g CO_2 eq.	62.27	77.21	106.09
Abiotic resource depletion	g Sb eq.	2.51E-03	3.01E-03	4.05E-03
Water scarcity	dm^3 water eq.	7.61	10.13	12.43

Table 3 Environmental performance of 1 unit of aluminium beverage cans according to the most relevant impact categories

Along the supply chain of the aluminium beverage cans, two activities are responsible for the main impacts: aluminium production and can manufacturing.

With regards to the "Climate change" category, which describes the effect on climate change of greenhouse gases emissions, the impact of aluminium production is due to the energy-intensive casting and rolling processes whereas the impact of can manufacturing is due to the electricity and heat consumptions and emissions into air.

The "Abiotic resource depletion" category, which describes the effect on the environment of fossil mineral resource depletion, the impact of aluminium production is due to the consumption of fluorspar and bauxite, whereas the impact of can manufacturing is due to consumption of indium and cadmium for plant infrastructure.

With respect to "Water scarcity", which describes the effect on the environment of water depletion, the impact of aluminium production is due to the aluminium ingot production, whereas the impact of can manufacturing is due to the hydroelectric electricity and water consumed at the plant.

Aluminium beverage cans are endlessly recyclable without substantial loss of quality, allowing for a significant reduction in virgin aluminium production. In the study, the recycling rate of aluminium beverage cans in Europe is set to 72.9% according to 2014 European statistics, meaning that almost 73% of the cans put on market are recycled into new aluminium products. From an LCA perspective, recycling aluminium beverage cans plays a fundamental role for the environment: for instance, for every 1000 cans recycled the reduction of greenhouse gases emitted into the air is between 61 and 86 kg CO_2 equivalent, as detailed in Table 4.

Impact category	Unit	25 cl	33 cl	50 cl
Climate change	kg CO_2 eq.	-61.03	-68.53	-85.99
Abiotic resource depletion	kg Sb eq.	-8.6E-04	-9.6E-04	-1.2E-03
Water scarcity	m^3 water eq.	-9.12	-10.24	-12.84

Table 4 Avoided environmental impact due to recycling of 1,000 units of aluminium beverage cans according to the most relevant impact categories

Therefore, it is important to maintain the recycling rate high and to improve it even further: in fact, an increase in the recycling rate by 5% would allow an average reduction of impact by 6% in Climate change, by 2% in Abiotic resource depletion and by 8% in Water scarcity (see Figure 3, Figure 4, Figure 5 for more details).

The LCA study evaluates also the environmental effect of the technical improvements occurred over the last 10 years (from 2006 to 2016) as regards aluminium production, can manufacturing and recycling rate. The results show significant reductions in CO_2-equivalent emissions by an impressive 31% on average for the three volumes.

The main factors which have made this progress possible are the continuous improvements taking place in the aluminium production and can manufacturing processes, a reduction in can weight and an increase in aluminium beverage can recycling rate.

For a 33 cl can, the reduction in Climate Change category over the 10-year period is 33% and includes the following key figures:

- a 12% reduction in the aluminium ingot supply;
- a 35% reduction in electricity and heat consumption, thanks to improved efficiency of can making process, as well as a 4% reduction in body can weight;
- almost a 50% increase in the aluminium beverage can recycling rate across Europe, going from 50% to 73% in 2014.

The results of the most relevant impact categories are indicated in Table 5 whereas the complete list of results is reported in Table 7.

Impact category	Unit	25 cl		33 cl		50 cl	
		2006	2016	2006	2016	2006	2016
Climate change	kg CO_2 eq.	94.8	62.3	115.4	77.2	145.1	106.1
Abiotic resource depletion	kg Sb eq.	3.9E-03	2.5E-03	4.9E-03	3.0E-03	6.3E-03	4.0E-03
Water scarcity	m^3 water eq.	10.5	7.6	13.6	10.1	16.5	12.4

Table 5 Comparison of 2006 versus 2016 scenarios of the environmental performance of 1,000 units of aluminium beverage cans according to the most relevant impact categories

The LCA study was successfully peer-reviewed by an independent third party. Additional information is available in the next paragraph.

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ADDITIONAL INFORMATION

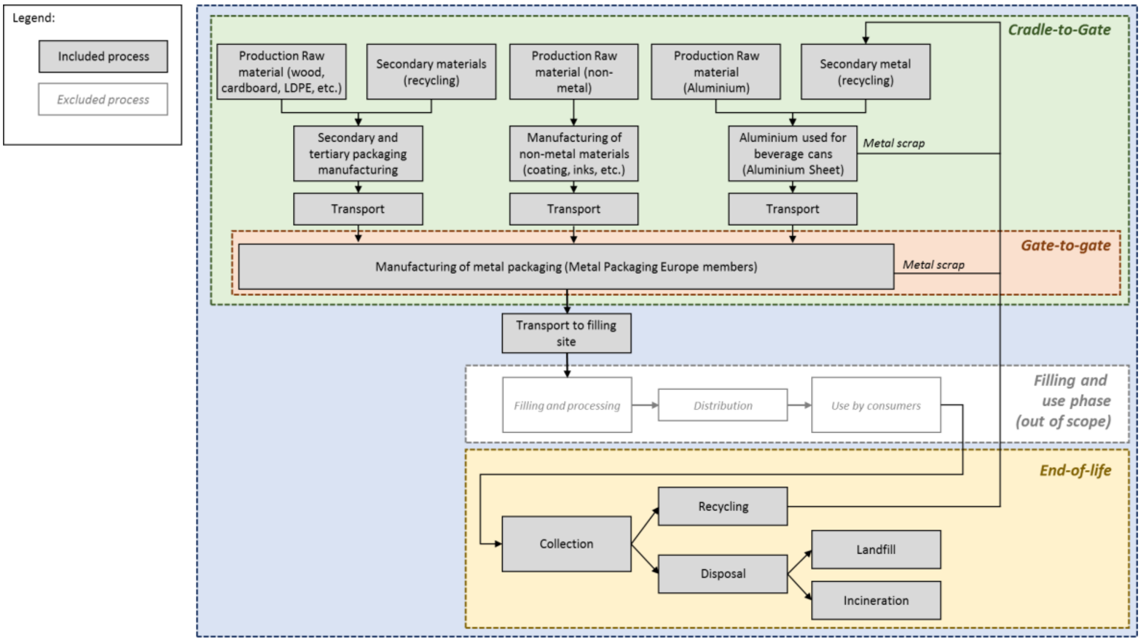

Figure 1 System boundaries of the LCA study

Country	#plants	Repres. of sold tons
AT - Austria	2	5-10%
DK - Denmark	1	<5%
FI - Finland	1	<5%
FR - France	2	5-10%
DE - Germany	4	15-20%
EL - Greece	2	<5%
IT - Italy	1	<5%
IRL - Ireland	1	<5%
NL - Netherlands	1	<5%
PL - Poland	1	<5%
SK - Slovakia	1	<5%
SRB - Serbia	1	<5%
ES - Spain	2	5-10%
UK - United Kingdom	4	20-30%
TR - Turkey	2	<5%
TOTAL	**26**	**100%**

Figure 2 Geographical coverage of the study by country, number of plants and production

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The full environmental performance of the aluminium beverage cans is reported in Table 6. The avoided impacts (of substituting virgin aluminium production with recycled aluminium beverage cans) are fully allocated to the life cycle of the aluminium beverage cans according to the following parameters for "open-loop" scenario: recycling rate 72,9%, recycled content 40%, allocation ratio 0% ("End-of-Life" allocation approach).

MPE supports the full allocation of environmental benefits to the life cycle of metal packaging as the best way to reflect in LCA the property of metals to be endlessly recyclable.

Impact category	Unit	25 cl	33 cl	50 cl
Climate change	kg CO_2 eq.	62.27	77.21	106.09
Abiotic resource depletion	kg Sb eq.	2.51E-03	3.01E-03	4.05E-03
Water scarcity	m^3 water eq.	7.61	10.13	12.43
Acidification	Moles H+ eq.	2.61E-01	3.17E-01	4.25E-01
Photochemical ozone formation	Mass C2H4 eq.	1.04E-01	1.24E-01	1.66E-01
Eutrophication freshwater	kg P eq.	9.09E-04	1.20E-03	1.51E-03
Respiratory inorganics	kg $PM_{2.5}$ eq.	1.99E-02	2.45E-02	3.38E-02
Stratospheric ozone depletion	kg CFC11 eq.	3.09E-06	4.03E-06	5.64E-06
Ionising radiation	kg U_{235} eq.	4.10E-05	4.78E-05	6.12E-05
Eutrophication terrestrial	Moles N eq.	5.79E-01	7.15E-01	9.52E-01
Eutrophication marine	kg N eq.	3.11E-02	3.62E-02	4.68E-02
Land use	Mass deficit of Soil Organic Carbon	80.83	100.47	139.27
Toxicity human	CTU	1.19E-06	1.60E-06	2.29E-06
Ecotoxicity freshwater	CTU	311.42	461.48	777.08

Table 6 Environmental performance of 1,000 units of aluminium beverage cans

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The assessment of the environmental effect of technical improvements occurred over the last 10 years (from 2006 to 2016) is reported in Table 7. The assessment is based on: MPE members' data collected for 2006 and 2016 production years, aluminium production datasets published by European Aluminium in 2005 and 2015, aluminium beverage cans recycling rates published by European Aluminium in 2007 and 2018. All other parameters and datasets are equivalent to the 2016 scenario.

Impact category	Unit	25 cl		33 cl		50 cl	
		2006	2016	2006	2016	2006	2016
Climate change	kg CO_2 eq.	94.8	62.3	115.4	77.2	145.1	106.1
Eutrophication terrestrial	Moles N eq.	1.17	0.58	1.60	0.72	1.97	0.95
Ecotoxicity freshwater	CTU	422.1	311.4	588.3	461.5	903.1	777.1
Land use	Mass deficit of Soil Organic Carbon	88.8	80.8	113.9	100.5	151.5	139.3
Ionizing radiation	kg U_{235} eq.	3.3E-04	4.1E-05	4.0E-04	4.8E-05	4.9E-04	6.1E-05
Toxicity human	CTU	2.3E-06	1.2E-06	2.9E-06	1.6E-06	3.6E-06	2.3E-06
Eutrophication freshwater	kg P eq.	2.8E-03	9.1E-04	3.3E-03	1.2E-03	3.8E-03	1.5E-03
Acidification	Moles H+ eq.	0.495	0.261	0.643	0.317	0.800	0.425
Respiratory inorganics	kg $PM_{2.5}$ eq.	0.028	0.020	0.036	0.024	0.047	0.034
Stratospheric ozone depletion	kg CFC11 eq.	5.6E-06	3.1E-06	6.6E-06	4.0E-06	8.1E-06	5.6E-06
Photochemical ozone formation	Mass C_2H_4 eq.	0.161	0.104	0.202	0.124	0.257	0.166
Eutrophication marine	kg N eq.	0.051	0.031	0.064	0.036	0.079	0.047
Abiotic resource depletion	kg Sb eq.	3.9E-03	2.5E-03	4.9E-03	3.0E-03	6.3E-03	4.0E-03
Water scarcity	m^3 water eq.	10.5	7.6	13.6	10.1	16.5	12.4

Table 7 Comparison of 2006 versus 2016 scenarios of the environmental effect of technical improvements for 1,000 units of aluminium beverage cans

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The list of 14 impact categories used to assess the environmental performance of aluminium beverage cans is reported in Table 8.

Impact categories	Unit	Impact assessment model	Author	Recommended by
Climate change	kg CO_2 eq.	Bern model – Global Warming Potential over a 100-year horizon	Intergovernmental Panel on Climate Change, 2013	PEF 2017
Ozone depletion	kg CFC-11 eq.	EDIP model based on the ODPs of the World Meteorological Organization (WMO) over an infinite time horizon	WMO 1999	ILCD 2011
Human toxicity – cancer effects	CTUh	USEtox 2.0	USEtox 2.0	PEF 2017
Ecotoxicity for aquatic freshwater	PAF*m^3*day	USEtox 2.0	USEtox 2.0	PEF 2017
Particulate matter/ respiratory inorganics	kg $PM_{2.5}$ eq	RiskPoll model	Humbert, 2009	ILCD 2011
Ionizing radiations	kBq U_{235} eq	Human Health effect model	Dreicer et al., 1995	ILCD 2011
Photochemical ozone formation	kg NMVOC eq	LOTOS-EUROS model	Van Zelm et al., 2008 as	ILCD 2011
Acidification	mol H+ eq.	Accumulated Exceedance model	Seppälä et al., 2006;	ILCD 2011
Terrestrial eutrophication	mol N eq.	Accumulated Exceedance model	Posch et al., 2008	ILCD 2011
Freshwater eutrophication	kg P eq.	EUTREND model	Seppälä et al., 2006;	ILCD 2011
Marine eutrophication	kg N eq.	EUTREND model	Posch et al., 2008	ILCD 2011
Land use	kg C deficit	Soil Organic matter (SOM) model	Struijs et al., 2008	ILCD 2011
Water scarcity	m^3 water eq.	Available WAter REmaining (AWARE)	Boulay et al., 2016	PEF 2017
Abiotic resource depletion	kg Sb eq.	CML 2002 model	Milà I Canals et al.,	ILCD 2011

Table 8 Impacts categories analysed in the study

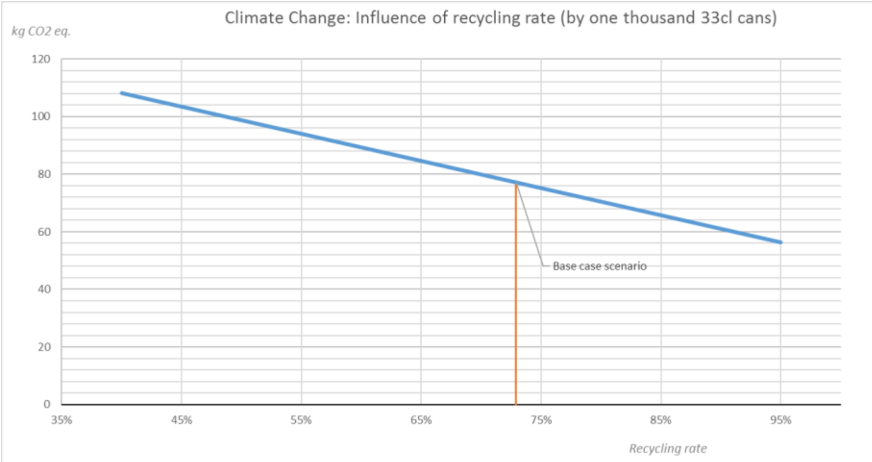

Figure 3: Influence of the recycling rate on Climate change impact for 33 cl cans

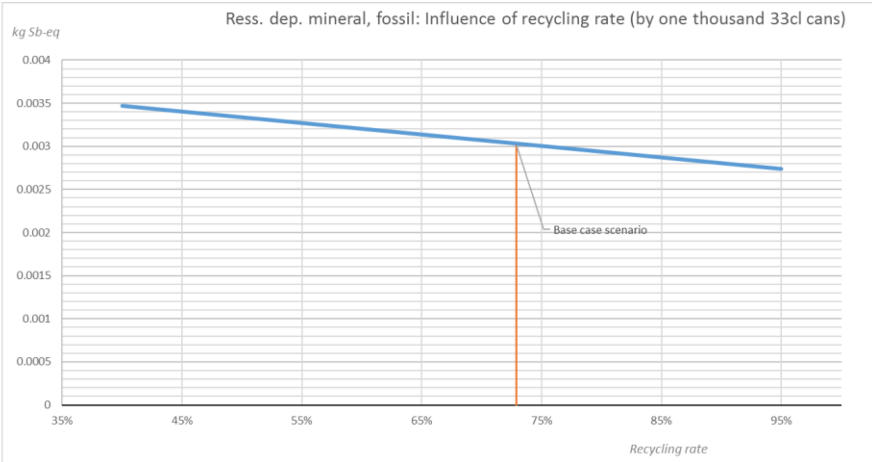

Figure 4 Influence of the recycling rate on Abiotic resource depletion impact for 33 cl cans

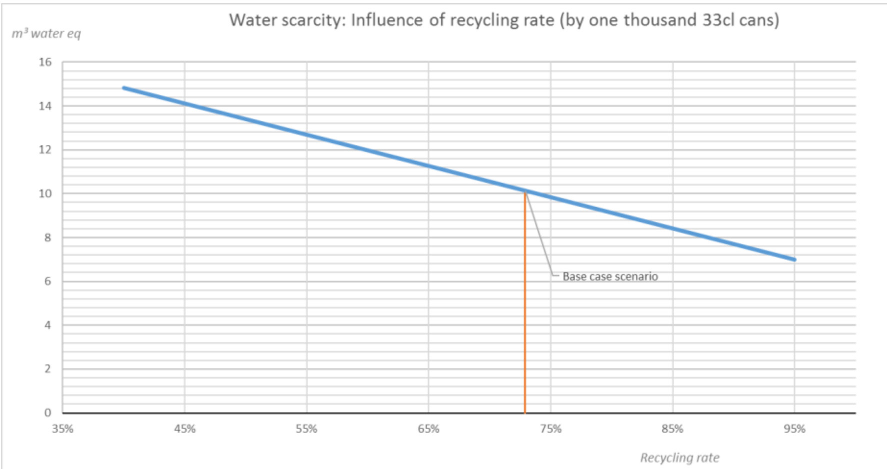

Figure 5 Influence of the recycling rate on Water scarcity impact for 33 cl cans

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The results of the LCA study are subject to the following limitations:

- Limitations inherent in the LCA methodology (ISO 14040:2016, 5.4.3)
- Life Cycle Impact Assessment (LCIA) cannot always demonstrate significant differences between impact categories and the related indicator results of alternative product systems
- The lack of spatial and temporal dimensions in the Life Cycle Inventory results introduces uncertainty in the LCIA results
- The level of uncertainty of the toxicity indicators are very high, especially for metals, due to the elementary flows (inventory) and the characterisation factors (USEtox methodology)
- Limitation due to potential methodological inconsistencies between background databases
- Limitation due to the approach to average the information collected from MPE members
- Limitation due to filling missing data
- Limitation due to simplified modeling for some minor raw materials
- Limitations due to the use of average recycling rate
- Limitations due to the geographical scope
- Limitations due to non-regionalized water consumption

The LCA study was successfully peer-reviewed by an independent third party (LCA expert Delphine Bauchot, Solinnen). As a whole, the expert considers that the final report answers to the goals which have been set up within the scope and limitations that are mentioned in the report.

More information is provided in the complete methodological report, available on request from the MPE secretariat.

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