Screening carbon footprint for aluminium wine packaging
Final report

Gaia Consulting

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Content

1. Introduction and background

1. Introduction and background

- The aim of this project was to conduct a screening carbon footprint calculation for aluminium wine packaging
- Results from this screening carbon footprint can be used for decision making, product development, internal communication and business-to-business communication
  - The results should not be used to make comparative assertions (e.g. between various materials) that are **disclosed to the public**
  - Later when there is sufficient primary data available from the production process, the screening carbon footprint can be updated to a standardized carbon footprint that can also be used in public marketing
- A light update for the LCA of other packaging materials was conducted in 2018*

* Update of wine packaging LCA – Final report Alko Oy, Gaia Consulting, 30.4.2018

2. Screening carbon footprint

2.1 Calculation methodology

Data:

- This calculation is only a screening calculation as no primary data has been used. The sources for secondary data were scientific publications and Ecoinvent
- Two calculations were done, in which different data was used for the production of the aluminium bottle:
  - Calculation 1: Results (not LCI data) from report "Life-cycle inventory data for aluminium production and transformation processes in Europe, European Aluminium, 2018." Most up-to-date data available for Europe
  - Calculation 2: Ecoinvent data
  - In both calculations same data (from Ecoinvent) was used for coating, closure and label production

Calculation methodology:

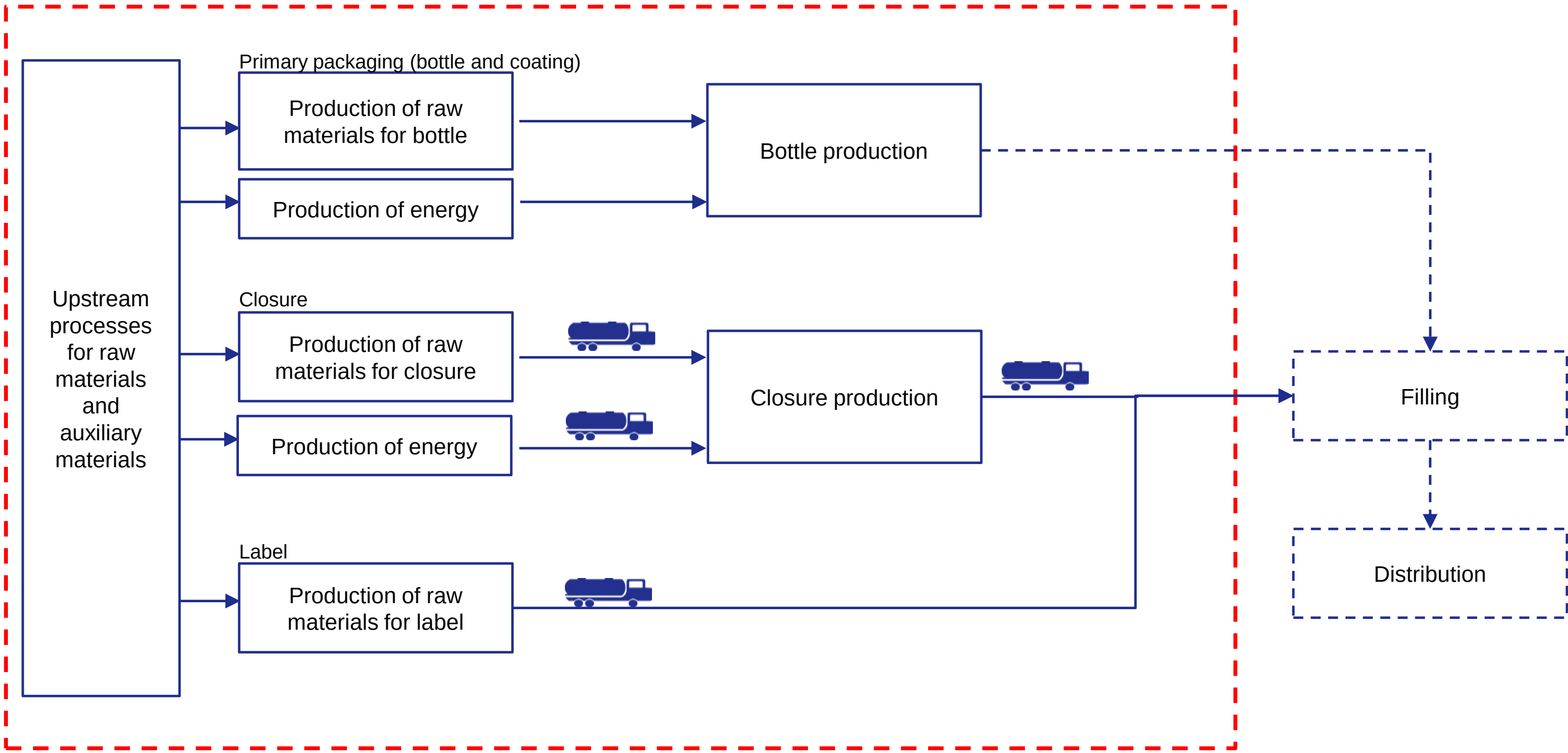
- SimaPro LCA software was used for calculations (SimaPro Analyst ver. 8.5.2.0)
- Ecoinvent 3.4 data library was used

It should be noted, that due to the used methodology the results are not comparable with the studies conducted in 2018. There are specific requirements (e.g. in ISO 14040/44) for studies which are used to make a comparative assertion (e.g. between various materials) that is disclosed to the public.

* For this report data was provided from year 2015 by the European Aluminium members for their own process steps. NOTE! The report is not a comparative LCI, and should not be used for comparative purposes between various materials (ISO 14040/14044)

2.2 Scope of the work

System boundary



The system boundary is based on definitions of calculations done in 2018. The system boundary includes production and raw materials supply for primary packaging, closure and label. For primary packaging, transportation of raw materials to bottle production (different scope from 2018 calculation) and bottles to filling stage are **not** included. For closure and label, transportation to filling stage is included. Filling and distribution are not included.

2.2 Scope of the work

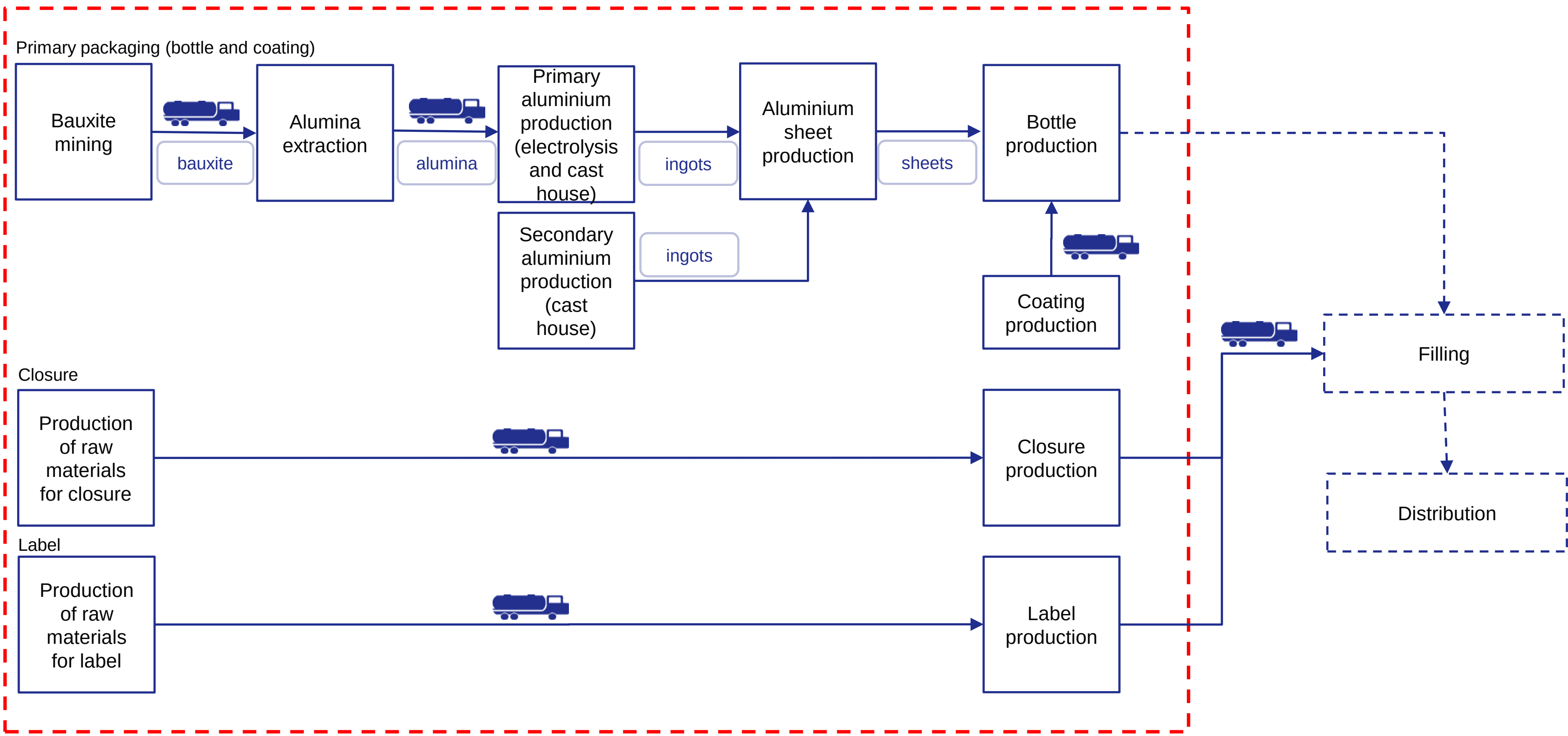
System boundary

Life Cycle "main stages"	Life Cycle stages	Life Cycle sub-stages	Definitions	NOT INCLUDED*
Packaging production	Primary packaging (bottle)	Primary packaging raw materials (aluminium and coating) and production & supply	Extraction, production and transport of the raw materials to the aluminium ingot producer	Transportation from: *Aluminium (ingot) production to sheet production *Sheet production to bottle production *Scrap aluminium to cast facility and to sheet production *Bottle to filling
		Packaging production	Energy, water and raw materials used in the process of producing the primary packaging (bottle)	
		Coating production	Energy, water and raw materials used in the process of producing the coating	Coating process of the aluminium bottle
	Closure	Closures raw materials and production & supply	Energy, water and raw materials used in the process of producing the closures and transport to filling	
	Labels	Labels raw materials and production & supply	Energy, water and raw materials used in the process of producing the labels and transport to filling	
	Secondary and tertiary packaging			Not included

* Infrastructure is not included in the European aluminium data and is also excluded from all Ecoinvent data used (as was also in 2018 calculation)

2.2 Scope of the work

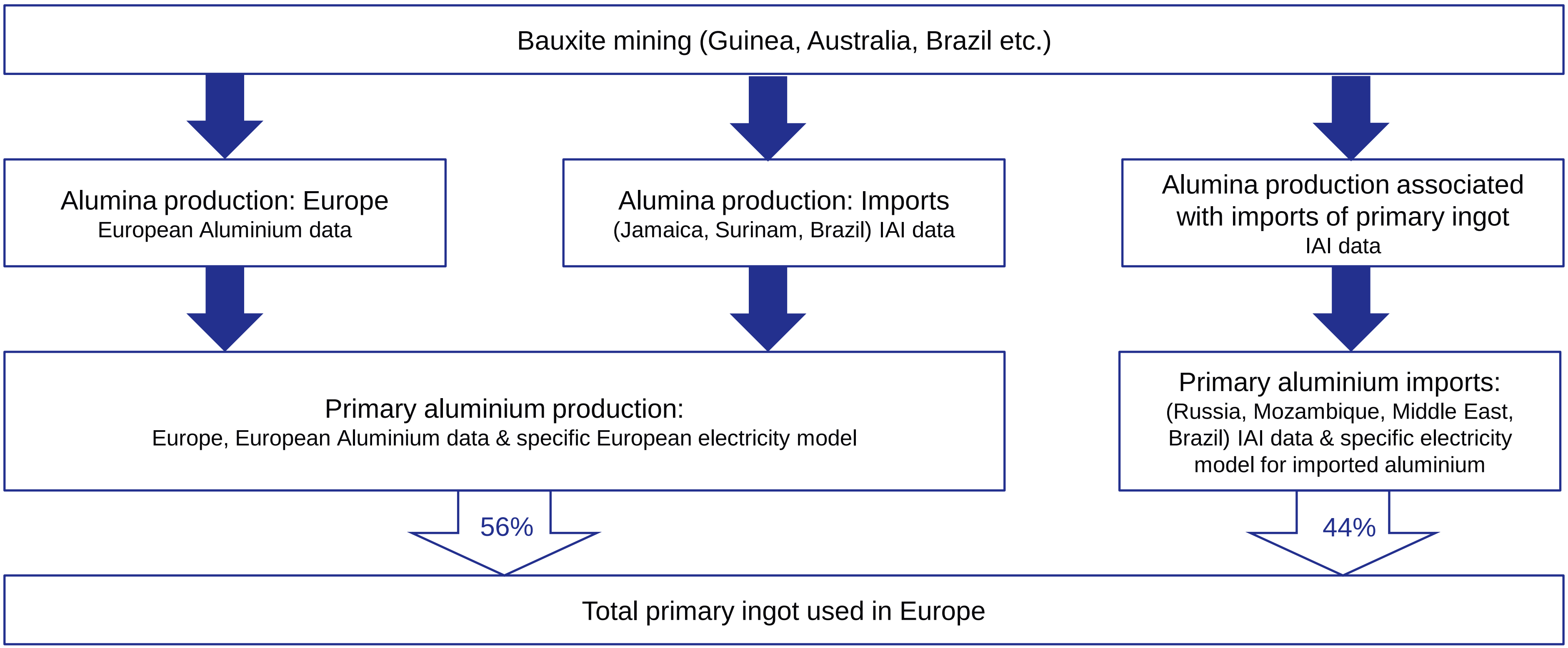
Aluminium bottle production



2.3 General on used data

Primary aluminium ingot production

- European aluminium data for primary aluminium ingot:



- More information on the used data from European aluminium report is presented in Appendix 1
- Similar background assumption are made in Ecoinvent data (older data 2010-2017)

2.4 Carbon footprint results for aluminium bottle

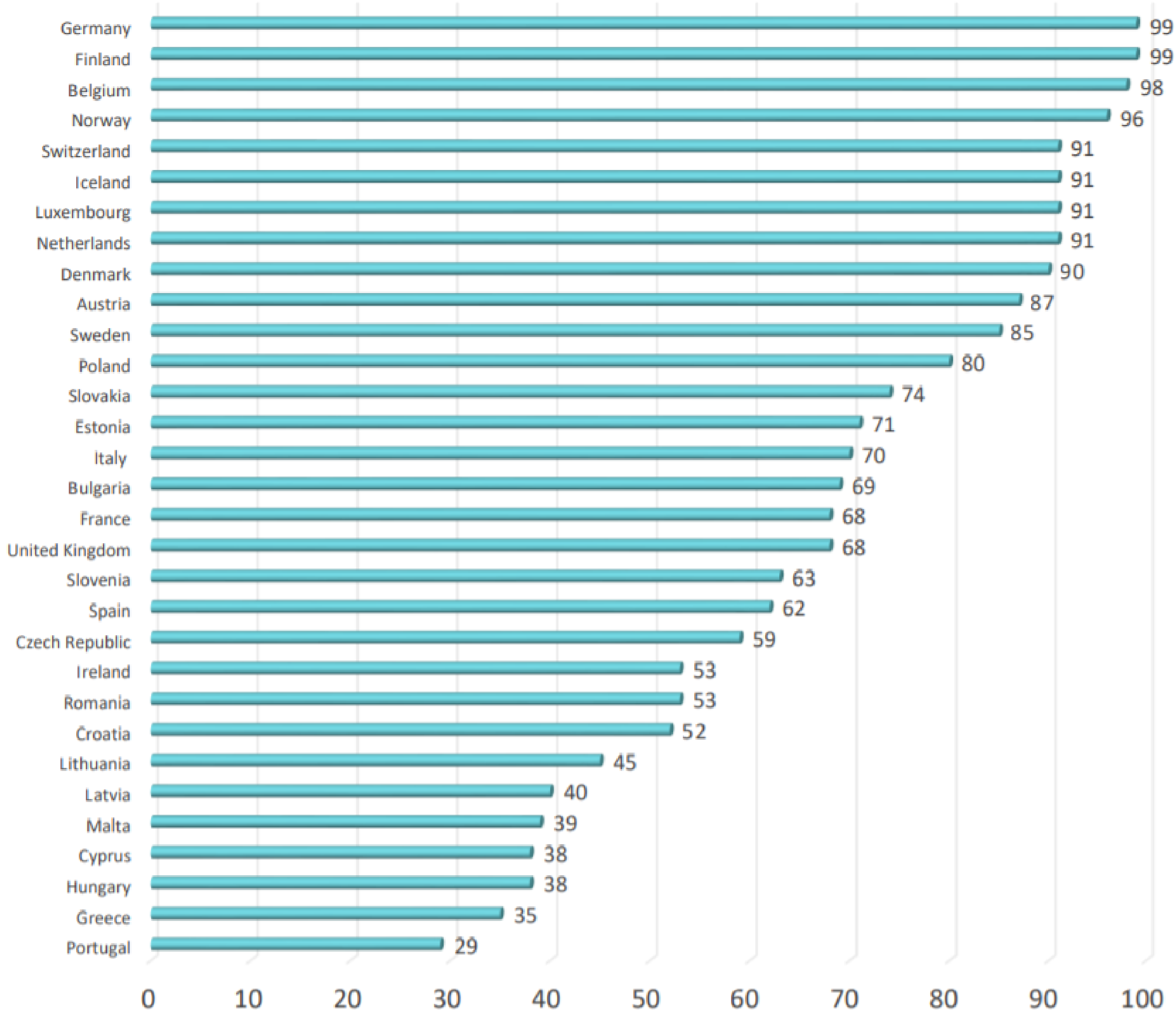
Aluminium recycling

- Results were calculated for:
  - 0% recycled aluminium
  - 50% recycled aluminium
  - 70% recycled aluminium

Facts on aluminium recycling*

- 75% of all the aluminium ever produced is still in use today
- Over half of all the aluminium currently produced in the European Union originates from recycled aluminium
  - E.g. Ball corporation estimates that on average the aluminum they use contains 68% recycled content
  - Novelis “evercan” is a beverage container made of 90% recycled aluminum.
- A recent study confirmed that beverage cans have, by far, the highest global recycling rate of all common beverage packaging substrates (c. 69 %).
  - Beverage can recycling rates are at or above 90 percent in several developed markets such as Belgium and Germany, as well as in developing markets, such as Brazil, where no formal packaging collection and recycling schemes yet exist.
- An average “can-to-can” lifecycle is just a couple of months - a can that is recycled today can be back on store shelves in just sixty days
- Recycling of aluminium and its alloys can be done without any loss of quality and requires much less energy than primary aluminium production

*References listed in Appendix 2



European aluminium beverage can recycling rates (2015, EU 28 + EFTA countries), data sources: EPR schemes (Green Dot, others), Deposit Refund Systems (cans only), EUROSTAT (metal / aluminium packaging), Industry Reports, PRN Notes (UK)

2.4 Carbon footprint results for aluminium bottle

Detailed results

		0% recycled aluminium kg CO2 eq. / 1000 l		50% recycled aluminium kg CO2 eq. / 1000 l		70% recycled aluminium kg CO2 eq. / 1000 l	
EA + Ecoinvent data	Calculation 1 (C1)						
Ecoinvent data	Calculation 2 (C2)						
		C1	C2	C1	C2	C1	C2
Primary packaging (bottle)	Primary aluminium (aluminium ingot)	349,6	384,0	200,7	244,0	141,2	188,0
	Scrap aluminium (gate to gate)						
	Sheet production (gate to gate)						
	Aluminium extrusion (gate to gate)*						
	Coating	18,6	18,6	18,6	18,6	18,6	18,6
Closure	Closure	69,3	69,3	69,3	69,3	69,3	69,3
Label	Lable	3,6	3,6	3,6	3,6	3,6	3,6
	TOTAL	**441**	**476**	**292**	**336**	**233**	**280**

*The extrusion process is not used for producing aluminium bottles from aluminium sheet. The extrusion process was used in this calculation as an approximate because there was no applicable process data available.

**For closure same amount of raw materials and transport were used as for class bottle in 2018 calculation. The results however differ, as different Ecoinvent data was used for the aluminium production and manufacturing processes.

2.4 Carbon footprint results for aluminium bottle

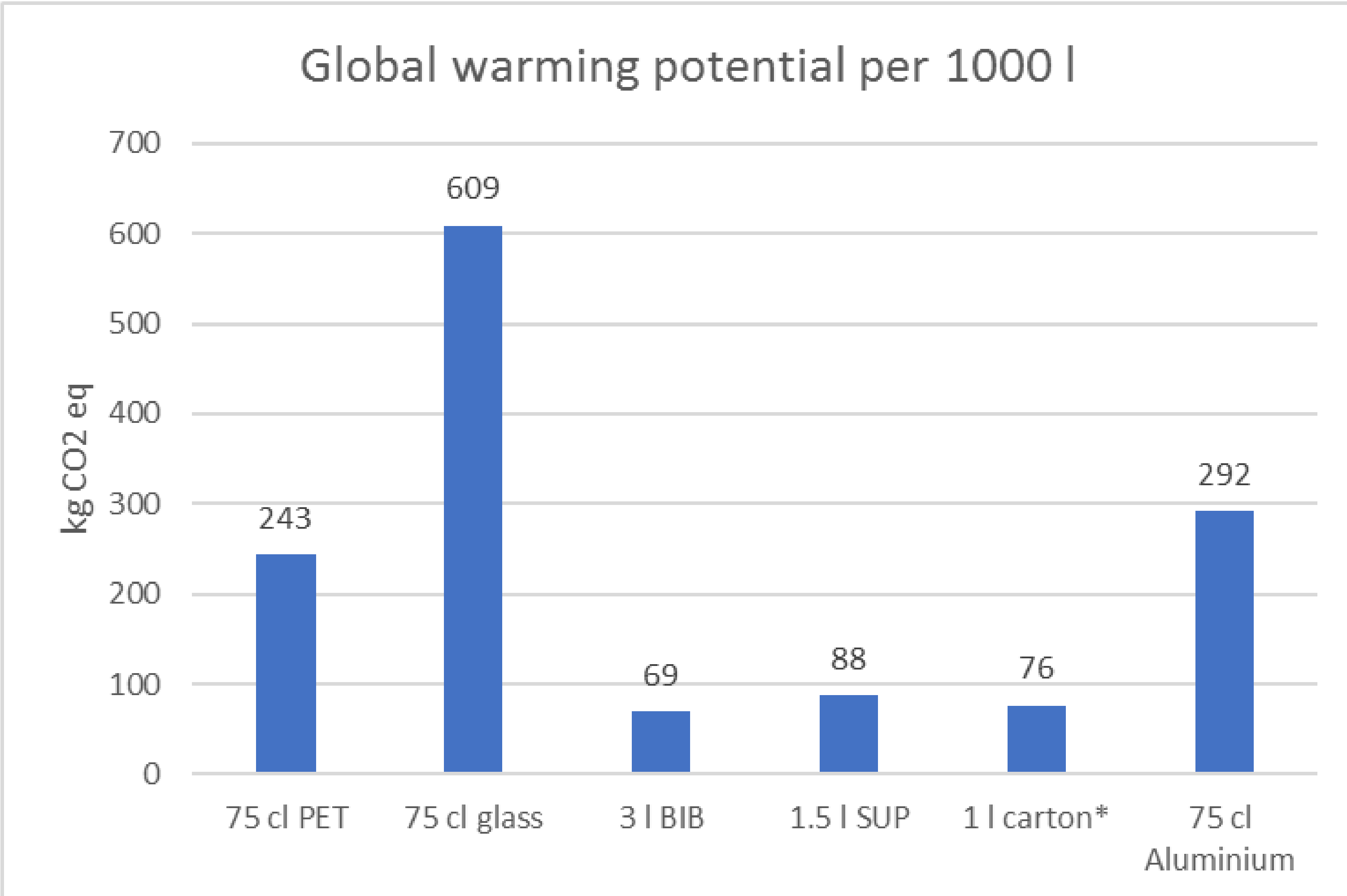
Main contributors of CO2 emissions

- Production of aluminium bottle has the major impact on the overall results
  - The largest impact comes from producing primary aluminium ingot. Most of the energy use in the electrolysis step
  - Production of semi-finished product (sheet) and final product bottle have smaller impact
  - For recycled aluminium emissions are reduced over 85% compared to the production of primary aluminium

		g CO2 eq. / kg product (from process step)	
		C1	C2
Primary packaging (bottle)	Primary aluminium (aluminium ingot)	8600	9140
	Scrap aluminium (gate to gate)	330	1340
	Sheet production (gate to gate)	430	587
	Aluminium extrusion (gate to gate)	680	945

2.5 Comparing different packaging types

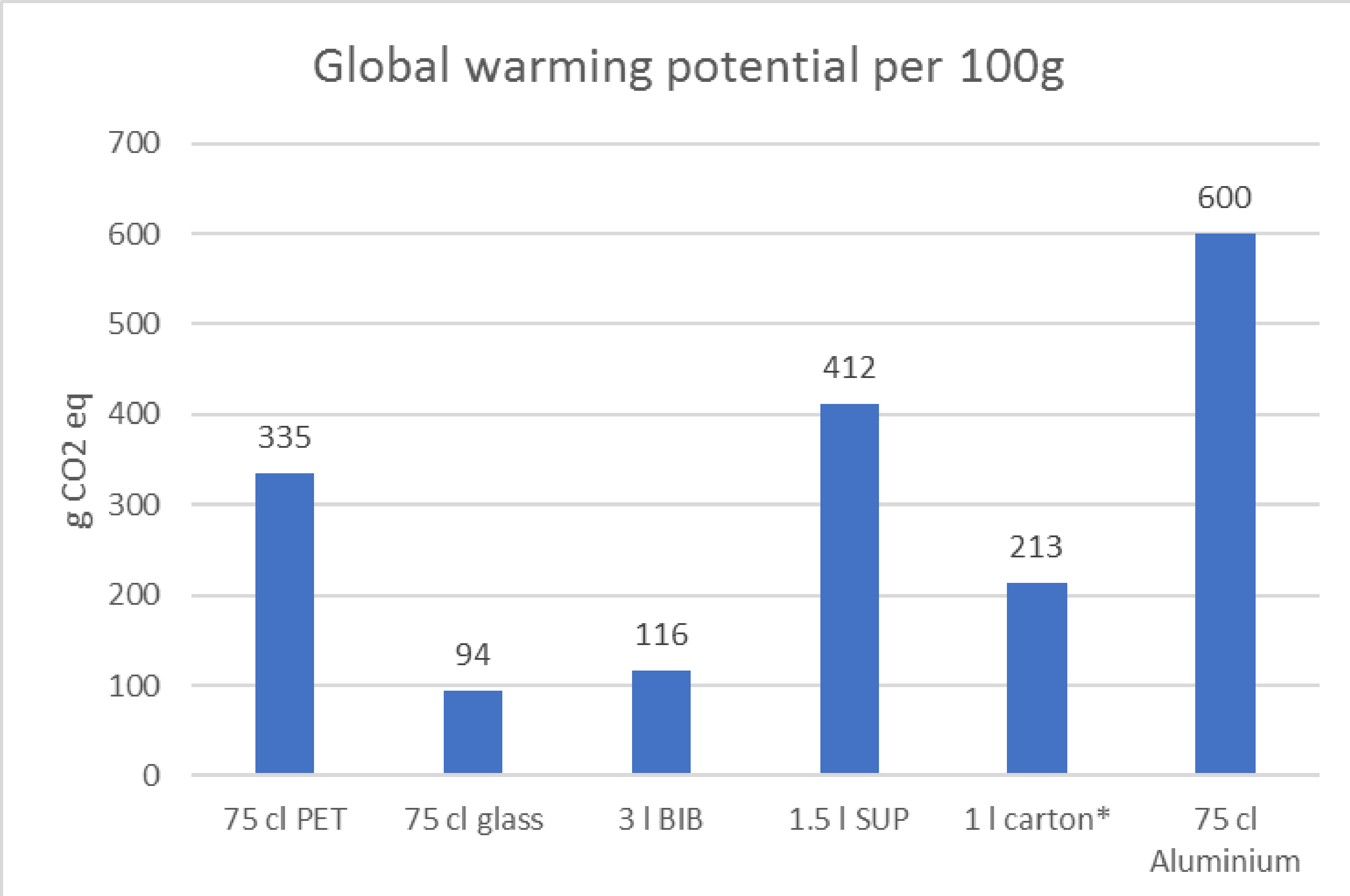
CO2 results per 1000 l of package* **(C1, 50% recycled aluminium)**



*The results for other than aluminum bottles have been taken from the previous report: Update of wine packaging LCA – Final report Alko Oy, Gaia Consulting, 30.4.2018

2.5 Comparing different packaging types

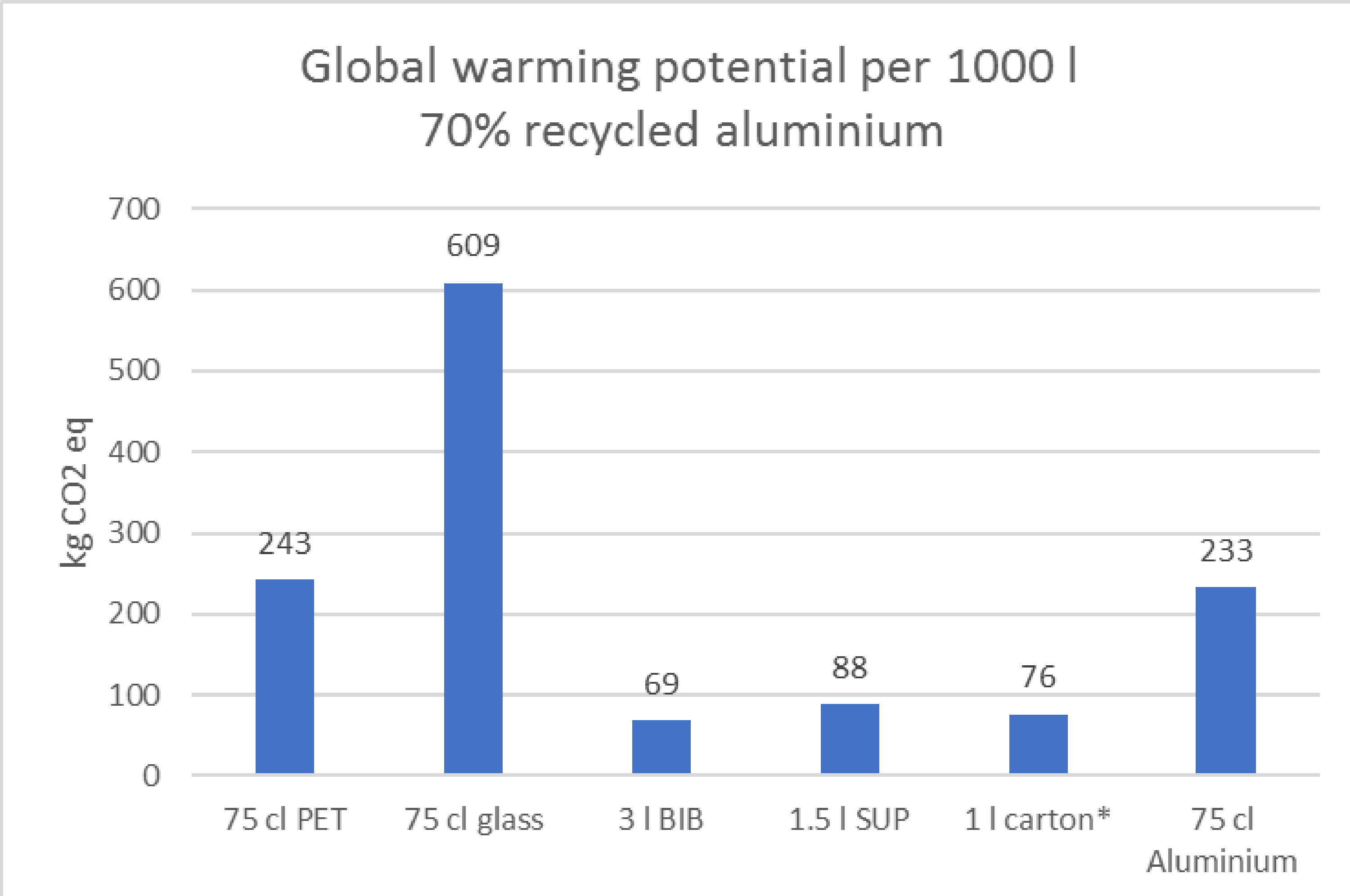
CO2 results per 100 g of package* **(C1, 50% recycled aluminium)**



*The results for other than aluminum bottles have been taken from the previous report: Update of wine packaging LCA – Final report Alko Oy, Gaia Consulting, 30.4.2018

2.5 Comparing different packaging types

CO2 results per 1000 l of package* **(C1, 70% recycled aluminium)**



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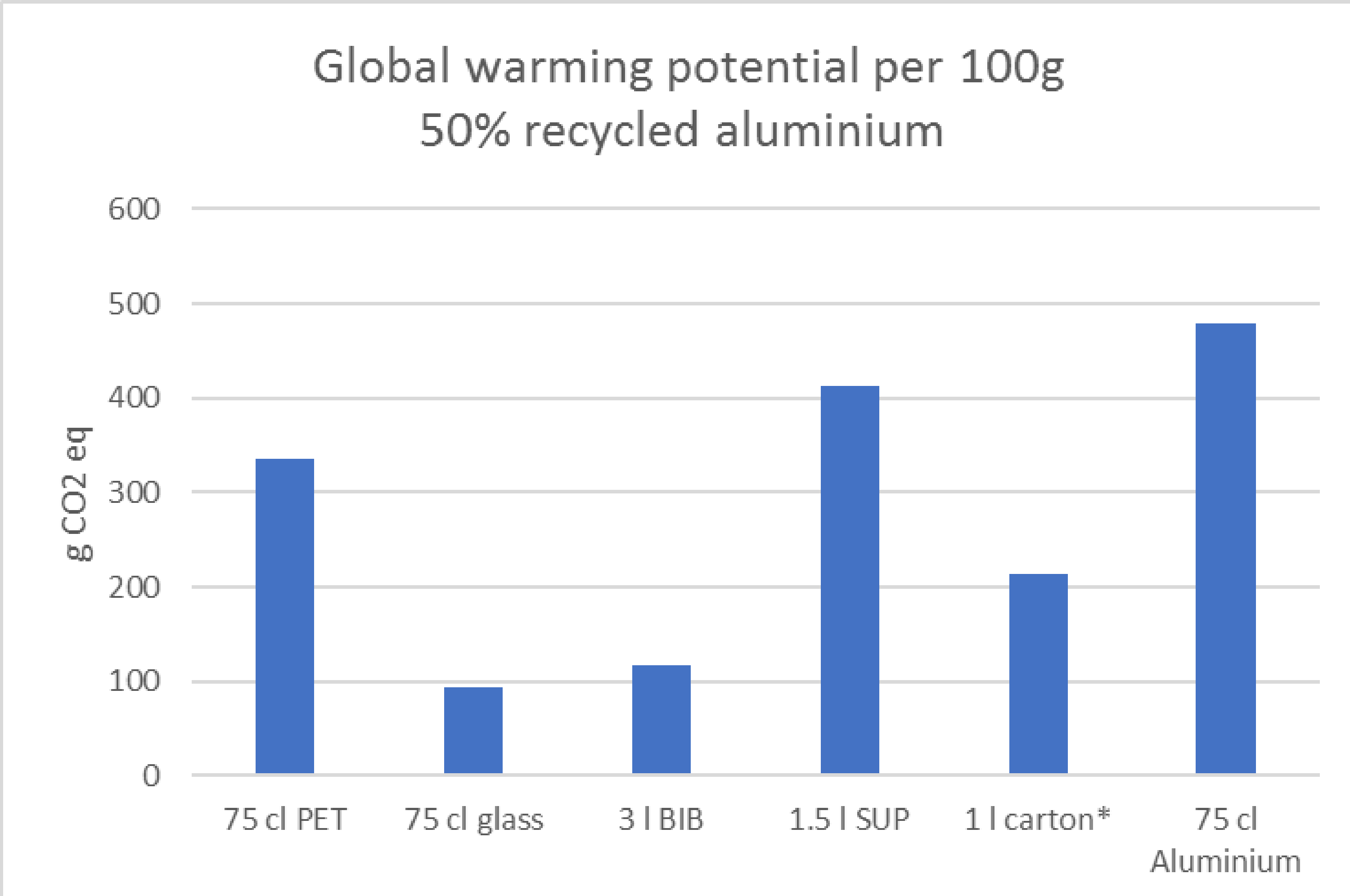

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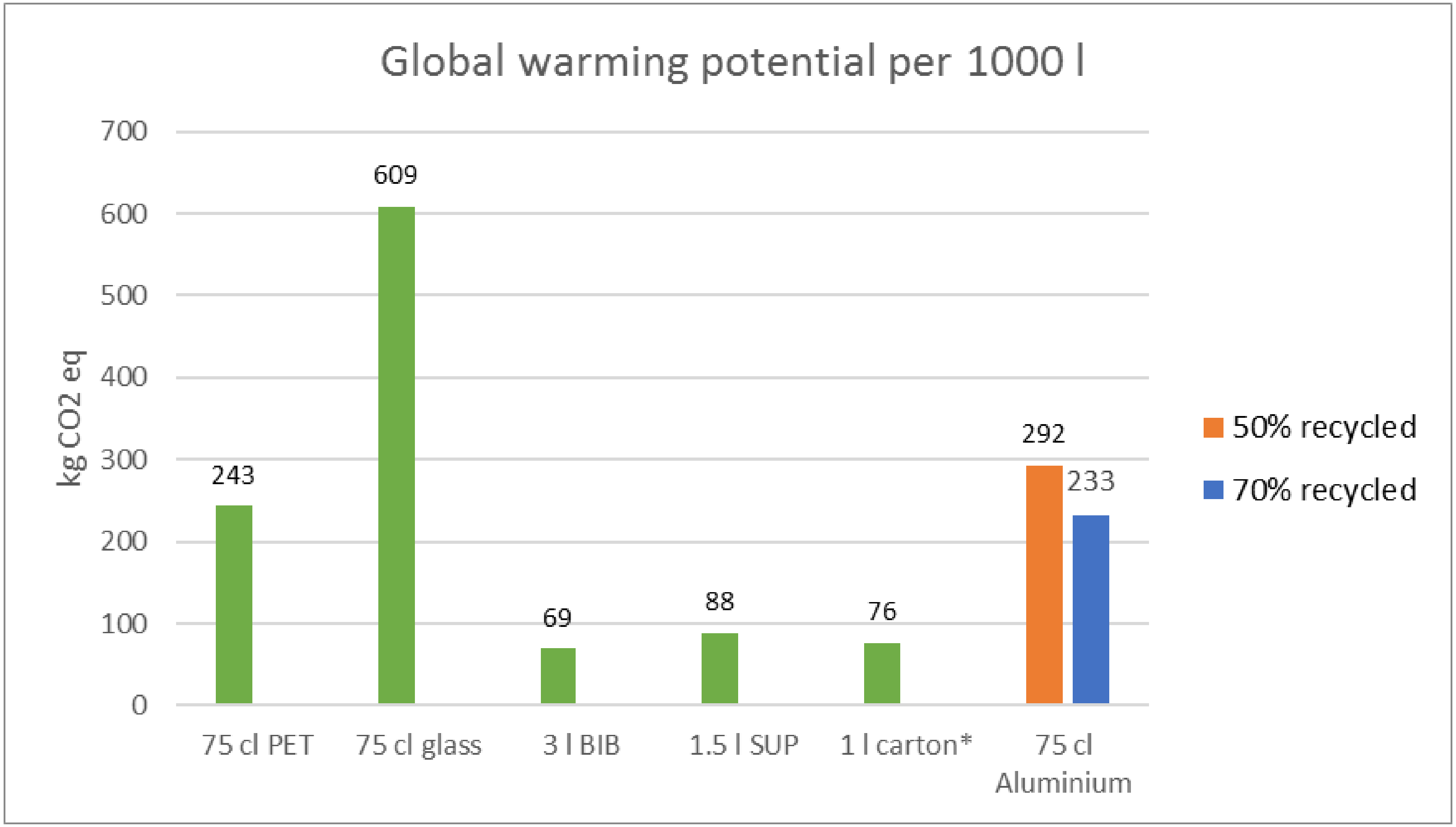
2.5 Comparing different packaging types

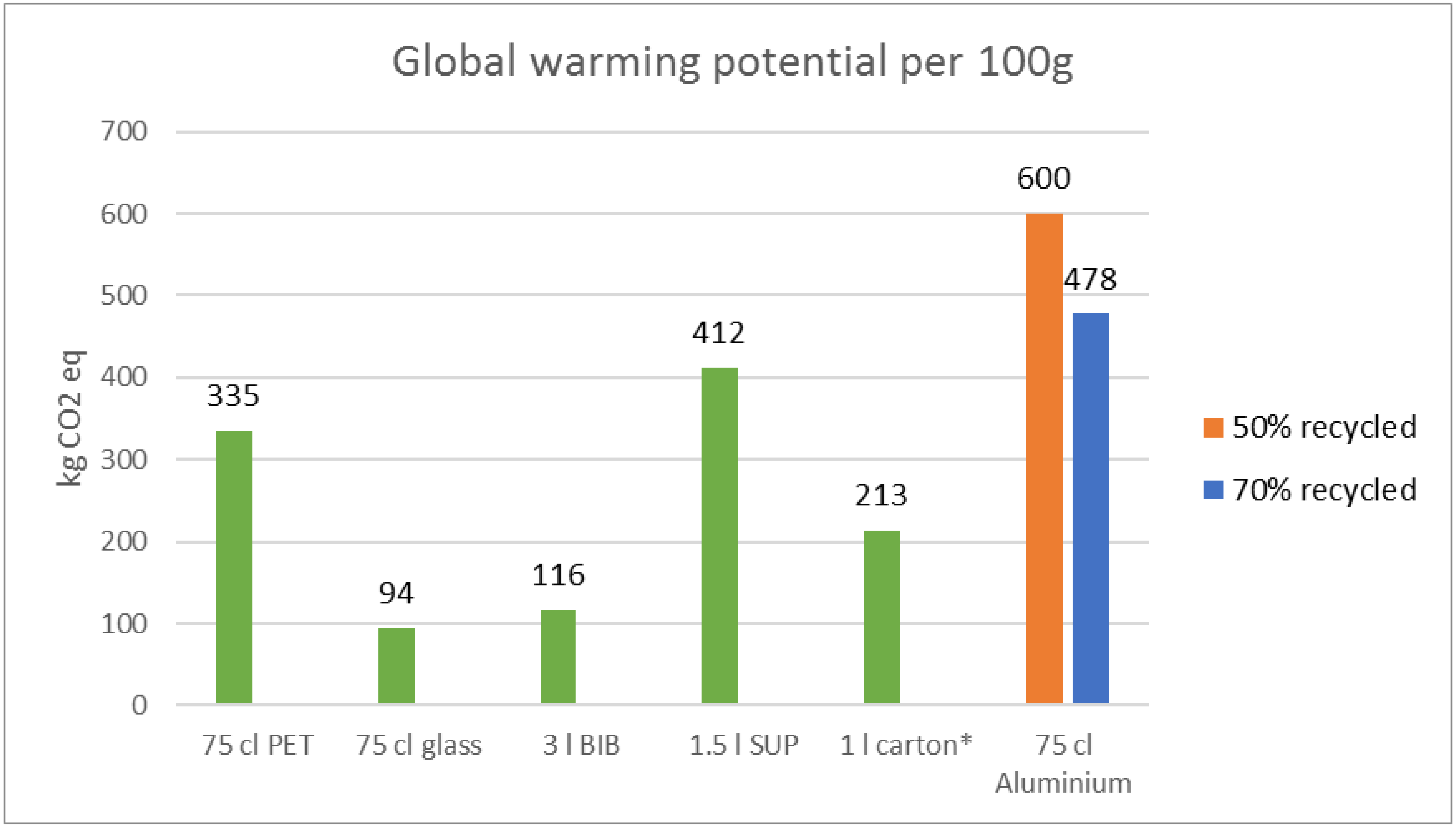
CO2 results per 1000 l of package* **(C1, 50% and 70% recycled aluminium)**



*The results for other than aluminum bottles have been taken from the previous report: Update of wine packaging LCA – Final report Alko Oy, Gaia Consulting, 30.4.2018

2.5 Comparing different packaging types

CO2 results per 100 g of package* **(C1, 50% and 70% recycled aluminium)**



*The results for other than aluminum bottles have been taken from the previous report: Update of wine packaging LCA – Final report Alko Oy, Gaia Consulting, 30.4.2018

3. Conclusions

- The production of the aluminium bottle has the main impact on the overall results
  - The largest impact comes from producing primary aluminium ingot. Most of the energy use in the electrolysis step
  - The production of semi-finished product (sheet) and final product (bottle) have a smaller impact
- The production of closure, label, coating as well as transportations have only a minor impact on the overall results
- In order to decrease environmental impacts, the recycle rate of used aluminium should be high
- The aluminium bottle has quite a similar CO2 footprint as a PET bottle (per 1000 l)
- Things to be noted, when using the results:
  - Due to the used methodology, the results of the calculation are not comparable with the original study conducted during the year 2018 and should not be disclosed to the public
  - The aluminium industry has also other environmental issues to consider - one of the major environmental issues is the disposal of massive amounts of bauxite residue

4. Disclaimers

- The report shall be provided based on the facts and instructions in the specific assignment considering the circumstances at the time of the assignment in accordance with the respective scope of work. We assume that all the information provided to us is accurate and complete and that you have verified the correctness of the disclosed information.
- We assume no responsibility and make no representations with respect to the accuracy or completeness of the information in this report unless otherwise stated. The report should not be regarded, or be relied upon, as a recommendation in decision making concerning any matter referred to in it.
- It should be understood that we do not assert that we have identified all matters included in these documents that may be relevant if these

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APPENDIX 1

More information on used data, calculation assumptions and emission factors used

European Aluminium: Life-Cycle inventory data for aluminium production and transformation processes in Europe

Data sources, assumption

Aluminium produced in Europe

- Bauxite mining
  - Data sources: Collected and developed by the International Aluminium Institute (IAI) for the year 2015
- Alumina production
  - Bayer chemical process
  - 2,2 t bauxite to produce 1 t alumina (4119 kg bauxite to produce 1 t primary ingot)
  - Thermal energy almost 100% natural gas
  - Data sources: Yearly input and output data was collected through questionnaires covering year 2015
- Electrolysis
  - Hall-Héroult process using prebake technology (95% of the primary aluminium in Europe was produced with this technology in 2015)
  - c. 2000 kg alumina to produce 1 t aluminium ingot
  - Data sources: Yearly input and output data was collected through questionnaires covering year 2015
- Casting (in smelters)
  - Average data for generic aluminium ingot
  - 1,001 kg liquid aluminium to produce 1 t ingot
  - A specific electricity model based on the electricity consumed by the European smelters

European Aluminium: Life-Cycle inventory data for aluminium production and transformation processes in Europe

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Data sources, assumption

Aluminium imported to Europe

- 49% of the primary aluminium used in Europe in 2015 was imported
- IAI data + Global data from the International Aluminium Institute used for modeling
- A specific electricity model for the electrolysis process based on the origins of the imports
- Since Europe is an important importer of alumina and primary aluminium, the modelling assumes that all alumina and primary aluminium produced in Europe is used in Europe

Transportation

- Average transport distances based on main import countries
  - Bauxite used in Europe is mainly imported from South America and Africa
  - Alumina used in Europe is mainly imported from Jamaica, Suriname and Brazil
  - Primary ingots mainly imported from Russia, Middle East and Mozambique

Table 2-6 *Average transport distances*

Year	Type of transport	Unit	Bauxite	Alumina	Primary
2010 and 2015	Ocean/Cargo	km	6 104	4 516	2 433
	Barge	km	-	200	88
	Road	km	4	5	-
	Rail	km	57	32	-

European Aluminium: Life-Cycle inventory data for aluminium production and transformation processes in Europe

Data sources, assumption

Aluminium sheet production

- C. 75 rolling mills in Europe, less than 10 companies represents c. 70% of the capacity
- Data sources: European Aluminium survey covering 88% for the cold rolled sheet production in Europe

Recycling:

- For aluminium cans, official European collection rate reached 70% in 2015
- More than 220 aluminium recycling facilities (refiners and smelters) in Europe
- Model is based on a mix of rotary and reverbatory furnace technologies (90%)
- Substitution methodology used (Recycled aluminium substitutes primary aluminium so that only metal losses during the whole life cycle needs to be balanced by primary aluminium)

European Aluminium: Life-Cycle inventory data for aluminium production and transformation processes in Europe

Data sources, assumption

Electricity model

- A precise model for the electrolysis step (most of the energy use)
- Three different models:
  1. Electricity used by European smelters using pre-bake technology
  2. Electricity used by European smelters using Soderberg technology
  3. Electricity used by smelters exporting to Europe (49% of the primary aluminium used in Europe is imported)

Table 4-10 *European electricity Model – Year 2015*

Consolidation at European level		***Calculating contribution of the various countries***	**Modelling of the electricity production**
Energy source	Share (in %)	*Main contributing countries (% of country in energy source)*	*LCI data used in the electricity model*
Hydro (or geothermal)	67%	EFTA (Norway and Iceland) countries (77%)	Norway
Nuclear	17%	France (45%); Germany (13%); Spain (12%)	France, Germany, Spain
Coal	9%	Germany (64%), Spain (21%); Greece (11%)	Germany, Spain, Greece
Natural gas	7%	Spain (24%), Germany (21%); Greece (16%)	Spain, Germany, Greece
Oil	0%	-	-
Total	**100%**	**-**	**-**

European Aluminium: Life-Cycle inventory data for aluminium production and transformation processes in Europe

Data sources, assumption

Electricity model

- Electricity used for the production of imported aluminium
- Countries listed in table below were considered in the model (represents more than 90% of the aluminium imported into Europe)

Table 4-12 *Geographical distribution of the primary aluminium main imports into Europe – 2010 (source Eurostat for EU27 and national customs data for EFTA countries)*

Regions	Imports share[14] (%)	2015 Main countries and percentage share of the region (in %)
Rest of Europe	43%	Russia (90%); Bosnia (5%) and Turkey (2%)
Africa	23%	Mozambique (62%); S. Africa (15%); Egypt (10%) and Cameroon (7%)
Middle East & Central Asia	21%	United Arab Emirates (79%); Bahrain (9%) and Tajikistan (3%)
North America	6%	Canada (93%) and USA (7%)
Central & South America	3%	Brazil (82%)
Asia	3%	India (48%); Malaysia (21%); China (14%)
Oceania	1%	New Zeeland (91%)
Total	**100%**	-

Data used from Ecoinvent

Aluminium bottle (75 cl, 27 g) Weight of 1000 l: 36 kg Total weight (with closure, label and coating): 48,7 kg			
Raw materials:	Weight [g]	Emission factor used	Calculation assumptions and other comments
Aluminium	27	Aluminium, primary, ingot {IAI Area, EU27 & EFTA}| production | Cut-off, U + Sheet rolling, aluminium {RER}| processing | Cut-off, U + Impact extrusion of aluminium, 1 stroke {RER}| processing | Cut-off, U	Recycled content 0%
		Aluminium, primary, ingot {IAI Area, EU27 & EFTA}| production | Cut-off, U Aluminium, secondary, from old scrap, at plant/RER U + Sheet rolling, aluminium {RER}| processing | Cut-off, U + Impact extrusion of aluminium, 1 stroke {RER}| processing | Cut-off, U	Recycled content 50%
		Aluminium, primary, ingot {IAI Area, EU27 & EFTA}| production | Cut-off, U Aluminium, secondary, from old scrap, at plant/RER U + Sheet rolling, aluminium {RER}| processing | Cut-off, U + Impact extrusion of aluminium, 1 stroke {RER}| processing | Cut-off, U	Recycled content 70%
Coating	2	Epoxy resin, liquid {GLO}| market for | Cut-off, U	Recycled content 0%
Aluminium sheet (closure)	5,5	Aluminium primary, ingot {IAI area, EU27 & EFTA}|production |Cut-off, U + Sheet rolling, aluminium {RER}| processing | Cut-off, U	Recycled content 0%
Paper (label)	2	Paper, woodfree, coated {RER}| paper production, woodfree, coated, at non-integrated mill | Cut-off, U Paper, woodcontaining, lightweight coated {RER}| production, woodfree, | Cut-off, U	Recycled content 50 %
Transportation:	tkm	Emission factor used	Calculation assumptions and other comments
Coating	0,667	Transport, freight, lorry >32 metric ton, EURO5 {RER}| transport, freight, lorry >32 metric ton, EURO5 | Cut-off, U	Same distances used as in 2018 calculation for glass bottle
Aluminium sheet (closure)	1,833	Transport, freight, lorry >32 metric ton, EURO5 {RER}| transport, freight, lorry >32 metric ton, EURO5 | Cut-off, U	Same distances used as in 2018 calculation for glass bottle
Paper (label)	0,667	Transport, freight, lorry >32 metric ton, EURO5 {RER}| transport, freight, lorry >32 metric ton, EURO5 | Cut-off, U	Same distances used as in 2018 calculation for glass bottle

APPENDIX 2

Sources

Appendix 2: Sources

Used for calculation

- Life Cycle Assessment on Aluminium Can and Glass Bottle for Packaging of 500 ml Beer, Nag, Rajat. 2015
- Environmental Profile Report: Life-Cycle inventory data for aluminium production and transformation processes in Europe, European Aluminium Association, 2018
- Environmental Profile Report for the European Aluminium Industry: Life Cycle Inventory data for aluminium production and transformation processes in Europe, European Aluminium Association, 2013
- How to builds better cans, Ball Corporation, 2019
- Update of wine packaging LCA – Final report Alko Oy, Gaia Consulting, 2018

Appendix 2: Sources

Some beverage packaging/aluminium bottle manufacturers in Europe

- Ball: Aluminium bottle and other beverage packaging
  - Production in Finland, Denmark, Germany, France, Poland, Italy, Austria, Spain, UK, the Netherlands (https://www.ball.com/eu/about-ball/contact-us/locations-map)
  - Sustainability report 2018 (https://www.ball.com/Ball/media/Ball/Ball2018_SustainabilityReport-_Web.pdf)
  - How Ball builds better cans (https://www.ball.com/Ball/media/Ball/Global/Downloads/How-Ball-Builds-Better-Cans_1.pdf?ext=.pdf)
- Crown: Beverage packaging
  - Plant locations in Europe Agoncillo, Spain; Sevilla, Spain; Valencia, Spain; Custines, France; Botcherby, UK; Korinthos, Greece; Patras, Greece; Parma, Italy; Košice, Slovakia; Izmit, Turkey; Osmaniye, Turkey (https://www.crowncork.com/about-crown/global-locations/beverage-plant-locations)
- Ardagh Group: Metal packaging production
  - 55 production facilities across Europe (https://www.ardaghgroup.com/metal/europe/our-markets#!beverage-cans)
- Novelis: Largest producer of aluminum beverage can sheet and the world's largest recycler of used beverage cans
  - Locations on North America, South America, Europe and Asia (http://novelis.com/aluminum-beverage-can/)
  - World's largest aluminum recycling center. Oroduces up to 400,000 metric tons of aluminum sheet ingot from recycled material. (http://novelis.com/nachtersted-recycling-center/)
  - "Evercan" (http://novelis.com/tag/evercan/ , https://www.theguardian.com/sustainable-business/2014/oct/30/recycled-aluminum-novelis-ford-cocacola-pepsi-miller-budweiser-beer). *Current situation unknown*

Appendix 2: Sources

Other sources

- European aluminium
  - Recycling Aluminium: a Pathway to a Sustainable Economy (https://www.european-aluminium.eu/media/1712/ea_recycling-brochure-2016.pdf)
- UPM recyclable labels
  - Self-adhesive labeling on beverage cans that are recyclability with aluminium cans (Craft beer in labeled and recyclable can)
- Environmental impacts of aluminium
  - OECD, Sustainable Material Management, Aluminium (http://www.oecd.org/environment/waste/46194971.pdf)
  - http://www.greenspec.co.uk/building-design/aluminium-production-environmental-impact/

Extra

Aluminium production in short

1) Bauxite mining	2) Alumina production	3) Making metal: Primary aluminium production mining	4) Using Aluminium

(https://www.european-aluminium.eu/about-aluminium/production-process/#)

1) Aluminium production begins with bauxite, the “aluminium ore”. Most bauxite is mined in tropical areas, with around 50 km^2 of new land mined each year. At the same time, a matching area of land is restored to nature
2) Pure aluminium oxide, called alumina, is extracted from bauxite via a process called refining, composed of two steps: a digestion process, using caustic soda, which allows the separation of aluminium hydroxide from the so-called “bauxite residue”, followed by a calcination step which removes the water content in the hydroxide. Both the aluminium hydroxide and the aluminium oxide have further applications outside of the metal industry.
3) Molten aluminium is extracted from the alumina through an electrolytic process called smelting, which breaks the strong chemical bond of the aluminium and oxygen atoms using a powerful electric current. Once the liquid metal is collected it is transferred in the casthouse, where it is purified, alloyed to specification and then cast into ingots.
4) The primary aluminium is cast into ingots and used in the production of aluminium alloys. Aluminium can be **rolled into sheets** from which aluminium foil and **beverage cans** are made, as well as parts of car bodies and a vast array or other products. Using the forming process of extrusion, the aluminium is shaped in its required form and delivers almost unlimited possibilities in product design.