CIRAIG MC

Centre interuniversitaire de recherche sur le cycle de vie des produits, procédés et services

Lab4 - Impact assessment and interpretation in LCA: Refrigerated water cans

EPFL

Step 1 - Preparation

- Download on Zenodo :

- Impact assessment method: IMPACT World +2.0.1

- Import it on OpenLCA

Reminder :

Right click on the ecoinvent database you already have – import – other – Linked Data.

Find your .zip – finish

Idem for IW+ import it in the same database

CIRAIG

Context

During the previous labs:

- Carbon footprint of the **consumption of a cooled carbonated water can** in the US (Lab1)
- Carbon footprint of an **alternative scenario** in which the aluminium cans are from Quebec and China (Lab2)
- Carbon footprint with different **recycling approaches** (Lab3)

→ Potential environmental impacts cradle-to-grave?

→ Interpretation ?

Contexte

Table 1: Inventory results for the reference scenario (FU = Drinking 1 can of refrigerated carbonated water, aluminum UE, 100% landfill, cut-off criteria at 11%)

Substance	Unit/ FU	[quantity]
Carbon dioxide, fossil	kg	1.69e-1
Chromium VI	kg	1.46e-6
Arsenic, ion	kg	9.82e-7
Particulates, <2.5um	kg	2.60e-4
Aluminium	kg	3.04e-5
Coal, hard, unspecified, in ground	kg	3.83e-2
Gas, natural, in ground	m^3	1.31e-2
Oil, crude, in ground	kg	8.08e-3
Coal, brown, in ground	kg	3.34e-2
Uranium, in ground	kg	4.79e-7
Water	m^3	3.51e-3

CIRAIG

Context

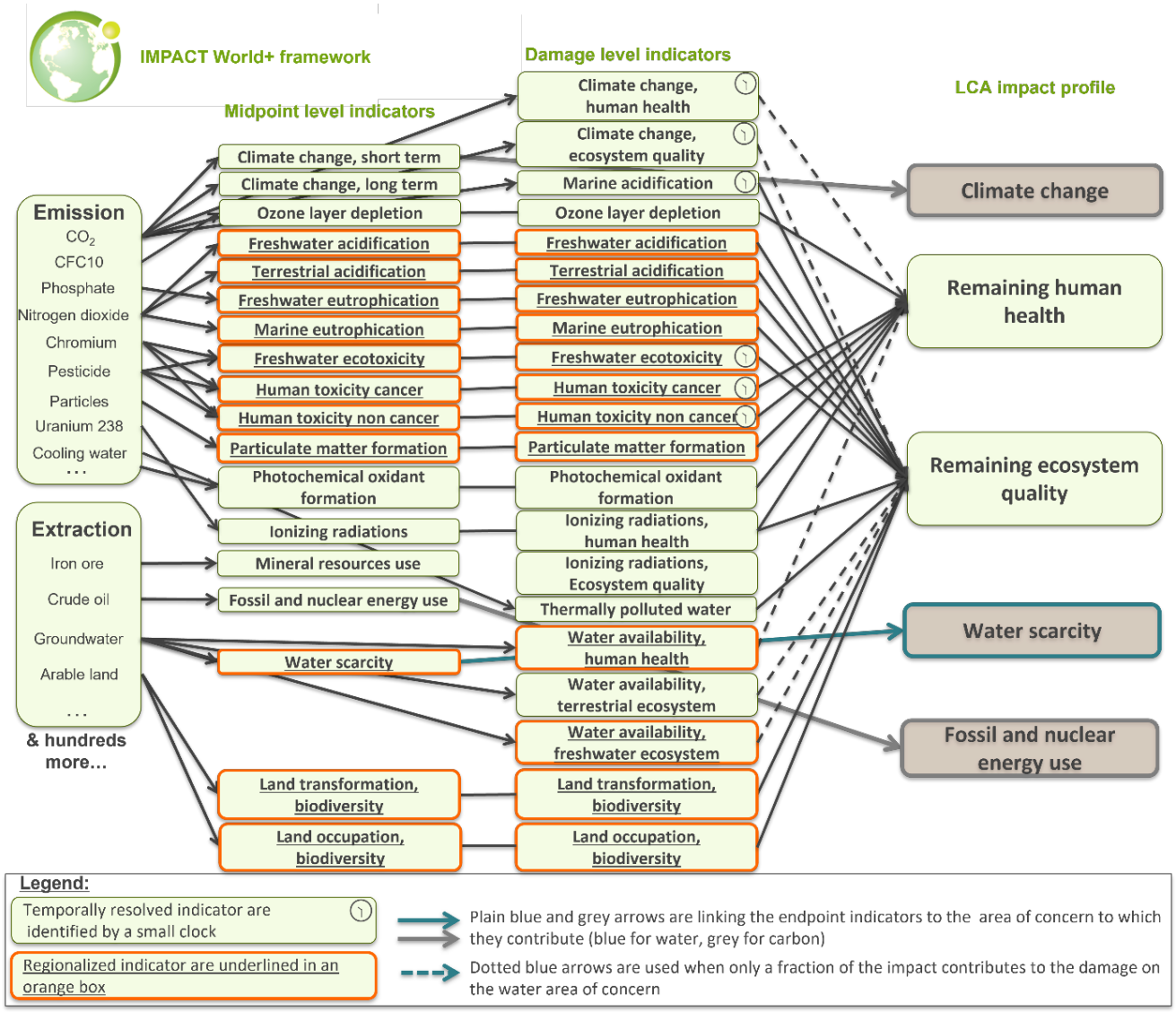


Figure 1: IMPACT World+ framework

Table 3: Impact categories, indicators, and indicators' unit of the Footprint version

Impact categories	Indicators displayed and units
Carbon footprint	- Climate change, short term (in kg CO_2 eq)
Water scarcity footprint	- Water scarcity (in m3 world-eq)
Resource depletion	- Fossil and nuclear energy use (in MJ deprived)
Rest of human health AoP (minus the contribution of climate change and water related issues)	- Rest of human health (in DALY)
Rest of ecosystem quality AoP (minus the contribution of climate change and water related issues)	- Rest of ecosystem quality (in PDF.m².yr)

Context

Table 2: Characterization factors of potential impacts (taken from IMPACT World+ method, footprint version)

Substance	**Carbon footprint** (kg CO2-eq)	**Fossil and nuclear energy use** ($MJ_{deprived}$)	**Water scarcity footprint** (m3 world-eq)	**Remaining human health damage** (DALY)	**Remaining ecosystem quality damage** (PDF.m2.yr)
Carbon dioxide, fossil (/kg)	1	-	-	-	0.0165
Chromium VI (/kg)	-	-	-	1.14E-1	5.32
Arsenic, ion (/kg)	-	-	-	7.19E-2	-
Particulates, <2.5um (/kg)	-	-	-	2.60E-4	-
Aluminium (/kg)	-	-	-	-	1080
Coal, hard, unspecified, in ground (/kg)	-	19.1	-	-	-
Gas, natural, in ground (/m3)	-	40.3	-	-	-
Oil, crude, in ground (/kg)	-	45.8	-	-	-
Coal, brown, in ground (/kg)	-	9.9	-	-	-
Uranium, in ground (/kg)	-	5.6e5	-	-	-
Water (/m3)	-	-	43.0	-	-

CIRAIG

Hand calculations

QUESTION 1

Question 1

1.1 Calculate by hand:

- the impact score of at least two categories (remaining human health and fossil and nuclear energy use)

1.2 Identify the elementary flow that contributes most to the impact scores.

Question 1

1.1 Impact scores:
Carbon footprint

Name	Inventory result	Unit	CF	Unit	Impact assessment result	Unit
Carbon dioxide, fossil	1.69E-01	kg	1.00E+00	kg CO2 eq (short)/kg	1.69E-01	kg CO2 eq (short)

CIRAIG

Question 1

1.1 Impact scores:

Fossil and nuclear energy use

Name	Inventory result	Unit	CF	Unit	Impact assessment result	Unit
Coal, hard, unspecified in ground	3.83E-02	kg	1.91E+01	MJ deprived/kg	7.32E-01	MJ deprived
Gas, natural, in ground	1.31E-02	m3	4.03E+01	MJ deprived/m3	5.27E-01	MJ deprived
Oil, crude, in ground	8.08E-03	kg	4.58E+01	MJ deprived/kg	3.70E-01	MJ deprived
Coal, brown, in ground	3.35E-02	kg	9.90E+00	MJ deprived/kg	3.32E-01	MJ deprived
Uranium, in ground	4.80E-07	kg	5.60E+05	MJ deprived/kg	2.69E-01	MJ deprived
					2.23	**MJ deprived**

CIRAIG

Question 1

1.1 Impact scores:

Remaining ecosystem quality damage

Name	Inventory result	Unit	CF	Unit	Impact assessment result	Unit
Aluminium	3.04E-05	kg	1.08E+03	PDF.m2.yr/kg	3.27E-02	PDF.m2.yr
Carbon dioxide, fossil	1.69E-01	kg	1.65E-02	PDF.m2.yr/kg	2.79E-03	PDF.m2.yr
Chromium VI	1.46E-06	kg	5.32E+00	PDF.m2.yr/kg	7.77E-06	PDF.m2.yr
					3.55E-02	**PDF.m2.yr**

CIRAIG

Question 1

1.1 Impact scores:

Remaining human health damage

Name	Inventory result	Unit	CF	Unit	Impact assessment result	Unit
Chromium VI	1.46E-06	kg	1.14E-01	DALY/kg	1.67E-07	DALY
Arsenic, ion	9.82E-07	kg	7.19E-02	DALY/kg	7.06E-08	DALY
Particulates, < 2.5 um	2.57E-04	kg	2.00E-04	DALY/kg	5.14E-08	DALY
					2.89E-07	**DALY**

CIRAIG

Question 1

1.1 Impact scores:

Water scarcity footprint

Name	Inventory result	Unit	CF	Unit	Impact assessment result	Unit
Water	3.52E-03	m3	4.30E+01	m3 world-eq/m3	1.51E-01	m3 world-eq

Question 1

1.2 Most contributory elementary flow (fossil and nuclear energy use)

Name	Inventory result	Unit	Impact assessment result	Unit	Contribution
Fossil and nuclear energy use			**2.23E+00**	**MJ deprived**	**100%**
Coal, hard, unspecified, in ground	3.83E-02	kg	7.31E-01	MJ deprived	33%
Gas, natural, in ground	1.31E-02	m3	5.27E-01	MJ deprived	24%
Oil, crude, in ground	8.08E-03	kg	3.70E-01	MJ deprived	17%
Coal, brown, in ground	3.35E-02	kg	3.32E-01	MJ deprived	15%
Uranium, in ground	4.80E-07	kg	2.69E-01	MJ deprived	12%

Question 1

1.2 Most contributory elementary flow (remaining human health damage)

Name	Inventory result	Unit	Impact assessment result	Unit	Contribution
Remaining Human health damage			**2.89E-07**	**DALY**	**100%**
Chromium VI	1.46E-06	kg	1.67E-07	DALY	58%
Arsenic, ion	9.82E-07	kg	7.06E-08	DALY	24%
Particulates, < 2.5 um	2.57E-04	kg	5.14E-08	DALY	18%

Question 1

1.2 Most contributory elementary flow (remaining ecosystem quality damage)

Name	Inventory result	Unit	Impact assessment result	Unit	Contribution
Remaining Ecosystem quality damage			**3.55E-02**	**PDF.m2.yr**	**100.00%**
Aluminium	3.04E-05	kg	3.27E-02	PDF.m2.yr	92.13%
Carbon dioxide, fossil	1.69E-01	kg	2.79E-03	PDF.m2.yr	8.52%
Chromium VI	1.46E-06	kg	7.77E-06	PDF.m2.yr	0.28%

Impact assessment in openLCA

QUESTION 2

Question 2

2 With openLCA

2.1 Compute the complete scores of the impact profile (i.e., the 5 categories of the footprint version of IMPACT World+) for the same reference product system based on the functional unit

2.2 Compare the results to the ones you obtained by hand. How do you explain the gap between those results?

Question 2

2.1. Compute the complete scores of the impact profile

Drinking of carbonated water

Impact analysis: IMPACT World+ Footprint v2.0.1

Sub-group by: (•) Flows ( ) Processes | Don't show < 1 %

Name	Category	Invent...	Char...	Impact assessment result
Carbon footprint	IMPACT World+ Footprint v2.0.1			0.20394 kg CO2 eq (short)
Fossil and nuclear energy use	IMPACT World+ Footprint v2.0.1			2.24139 MJ deprived
Remaining Ecosystem quality damage	IMPACT World+ Footprint v2.0.1			0.06958 PDF.m2.yr
Remaining Human health damage	IMPACT World+ Footprint v2.0.1			4.37880E-7 DALY
Water scarcity footprint	IMPACT World+ Footprint v2.0.1			0.15442 m3 world-eq

CIRAIG

Question 2

2.2. Compare the results to the ones you obtained by hand. How do you explain the gap between those results?

Drinking of carbonated water

Impact analysis: IMPACT World+ Footprint v2.0.1

Sub-group by: (•) Flows ( ) Processes | Don't show < 1 %

Name	Category	Invent...	Char...	Impact assessment result
Carbon footprint	IMPACT World+ Footprint v2.0.1			0.20394 kg CO2 eq (short)
Fossil and nuclear energy use	IMPACT World+ Footprint v2.0.1			2.24139 MJ deprived
Remaining Ecosystem quality damage	IMPACT World+ Footprint v2.0.1			0.06958 PDF.m2.yr
Remaining Human health damage	IMPACT World+ Footprint v2.0.1			4.37880E-7 DALY
Water scarcity footprint	IMPACT World+ Footprint v2.0.1			0.15442 m3 world-eq

0.169 kg CO2 eq
2.23 MJ deprived
0.0355 PDF.m2.yr
2.89E-07 DALY
0.151 m3 world-eq

CIRAIG

Calcul openLCA

QUESTION 3

CIRAIG

Question 3

3.1 Contribution analysis per process – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

- At the first modelling level (unit process feeding the reference flows)?
- At successive levels (upstream intermediate flows)?

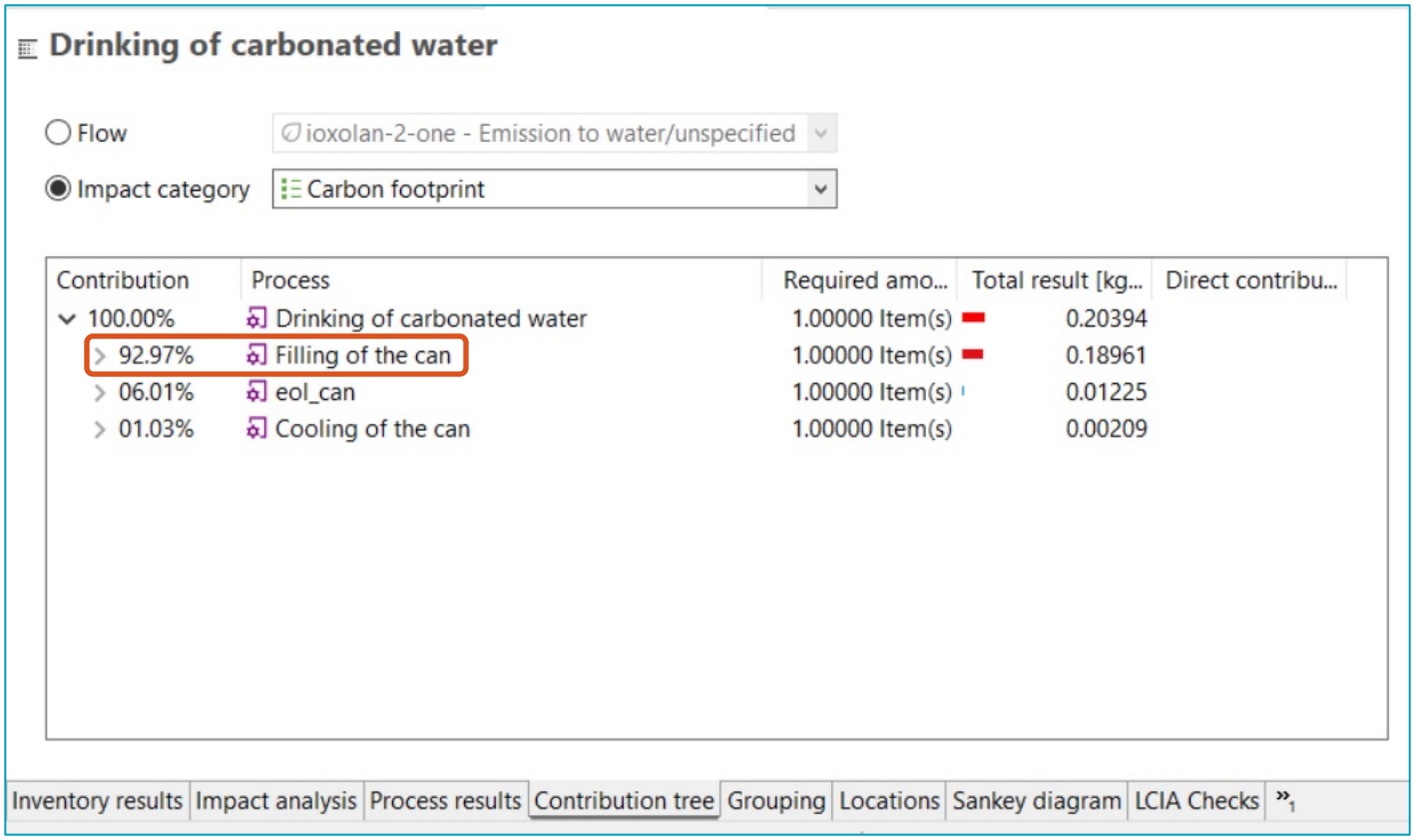
3.2 Contribution analysis per elementary flow to the 5 impact categories of the reference scenario.

- Which are the most contributing elementary flows to the HH and EQ areas of protection?
- Which are the most contributing elementary flows to climate change?
- Are the results on the environmental performance of the impact profile indicators consistent with the results obtained by hand?

Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

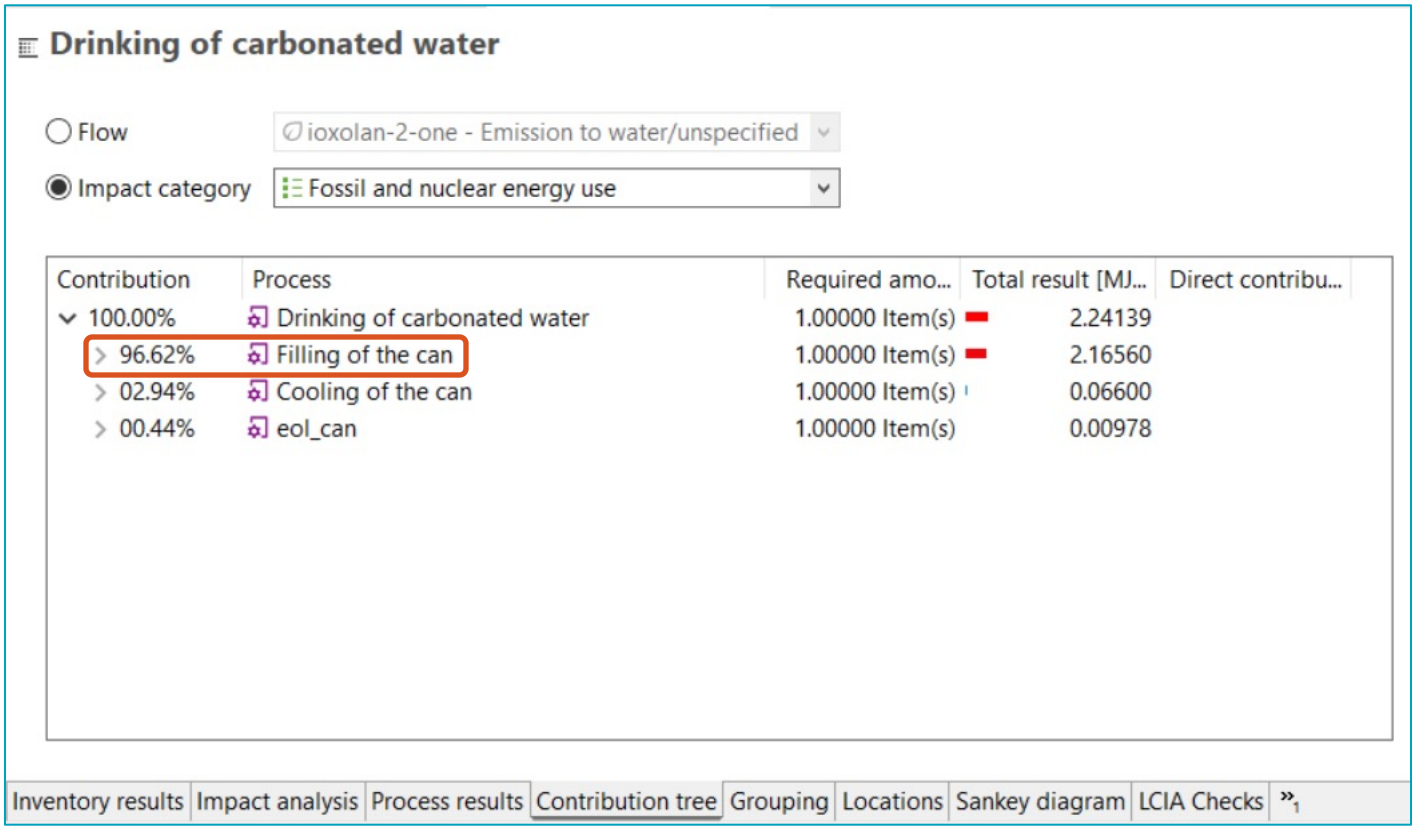
- At the first modelling level (unit process feeding the reference flows)?



Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

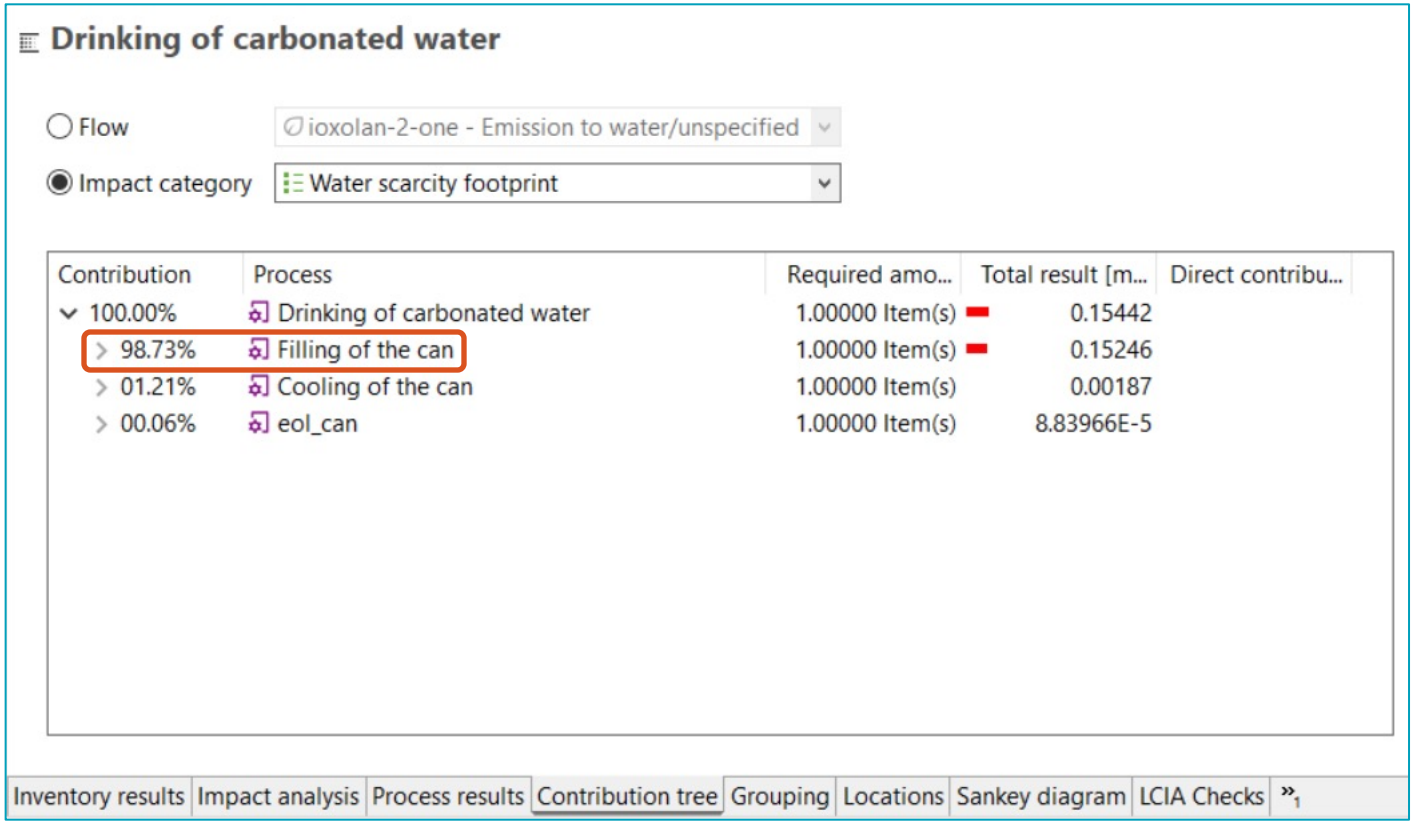
- At the first modelling level (unit process feeding the reference flows)?



Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

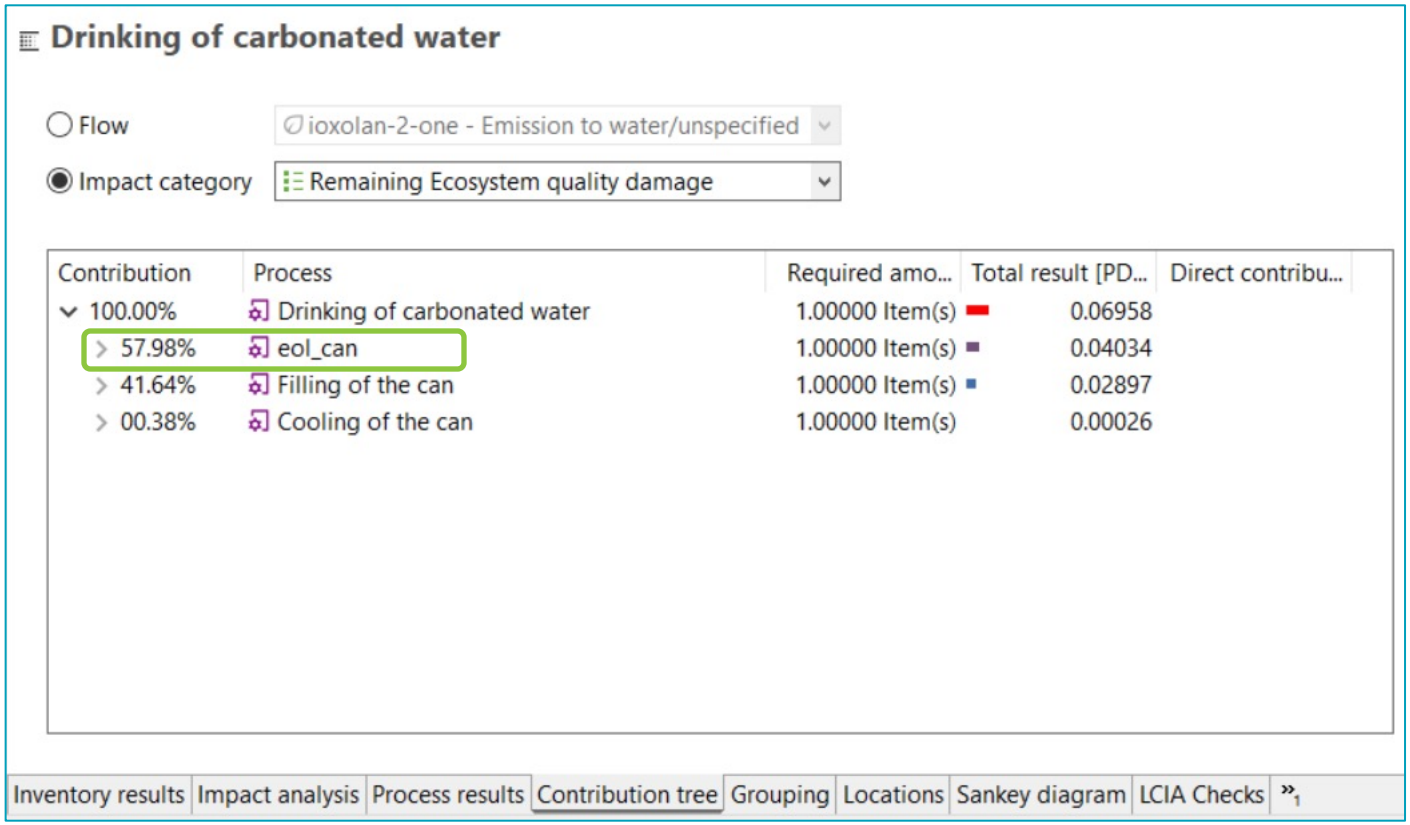
- At the first modelling level (unit process feeding the reference flows)?



Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

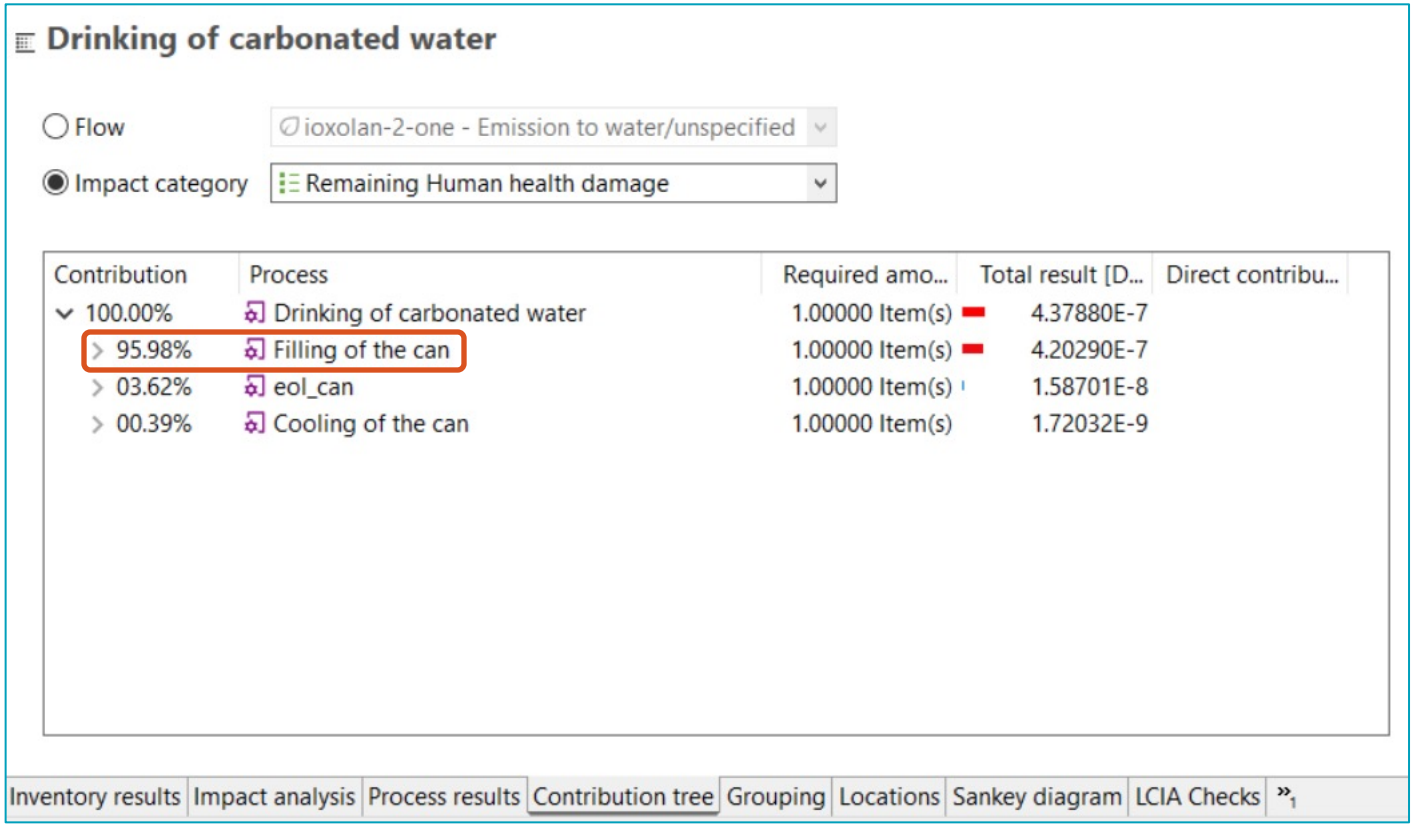
- At the first modelling level (unit process feeding the reference flows)?



Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

- At the first modelling level (unit process feeding the reference flows)?



Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

Transportation?

Drinking of carbonated water

Flow: ioxolan-2-one - Emission to water/unspecified

Impact category: Carbon footprint

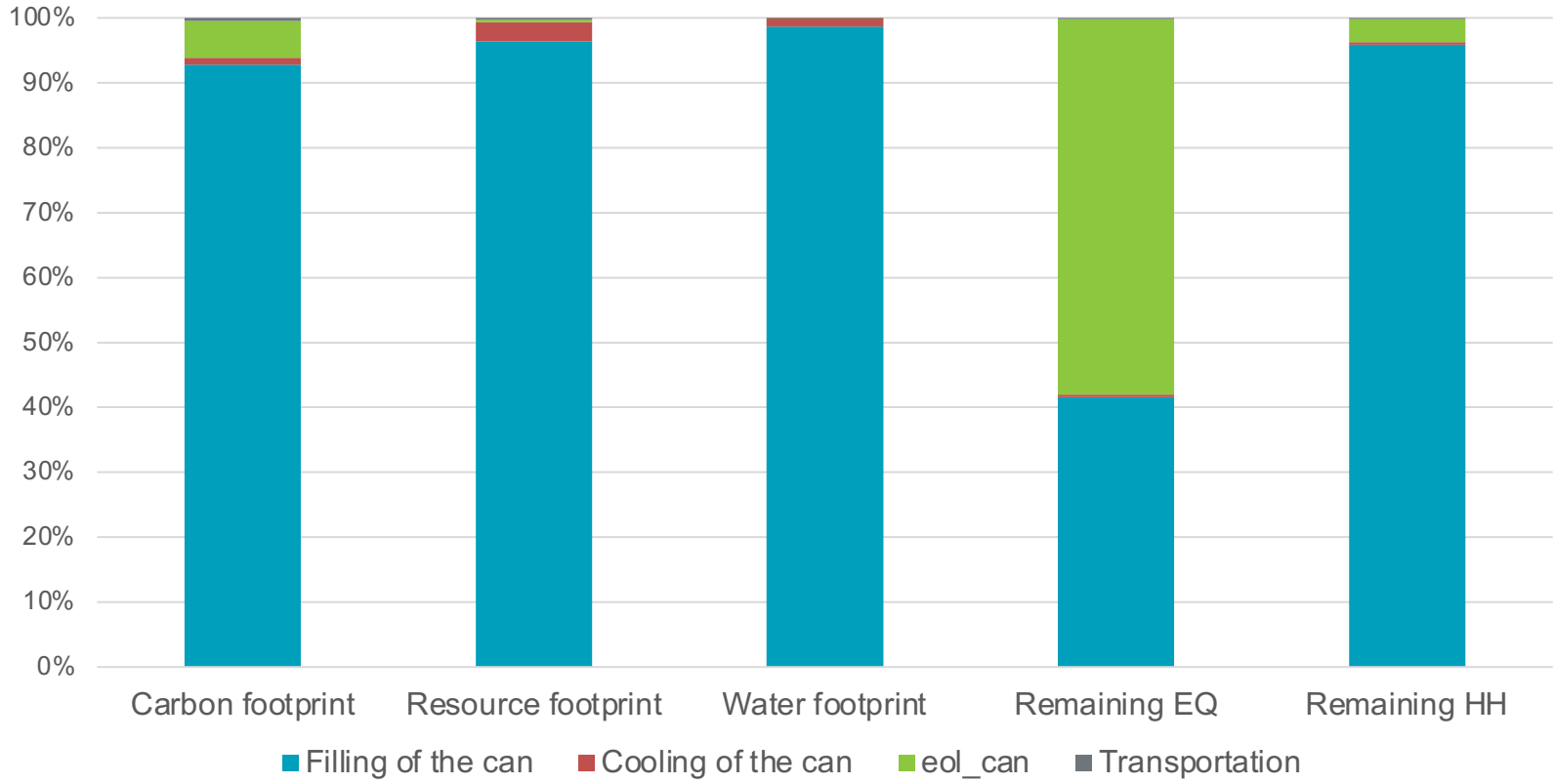
Contribution	Process	Required amo...	Total result [kg...	Direct contribu...
100.00%	Drinking of carbonated water	1.00000 Item(s)	0.20394	
92.97%	Filling of the can	1.00000 Item(s)	0.18961	
82.32%	Can production	1.00000 Item(s)	0.16789	0.00570
75.15%	aluminium production, primary, ingot | alum...	0.01300 kg	0.15326	0.15326
03.71%	electricity, high voltage, production mix | el...	0.10800 MJ	0.00757	0.00757
00.67%	market for natural gas, high pressure | natur...	0.00300 m3	0.00136	0.00136
08.61%	market for carbon dioxide, liquid | carbon di...	0.02000 kg	0.01757	0.01757
01.11%	electricity, high voltage, production mix | el...	0.03240 MJ	0.00227	0.00227
00.73%	market for transport, freight, lorry, unspecifi...	0.01100 t*km	0.00150	0.00150
00.19%	market for tap water | tap water | Cutoff, S - ...	0.35500 kg	0.00038	0.00038
06.01%	eol_can	1.00000 Item(s)	0.01225	
05.75%	market for municipal solid waste | municipal...	0.01300 kg	0.01172	0.01172
00.26%	market for transport, freight, lorry, unspecifi...	0.00390 t*km	0.00053	0.00053
01.03%	Cooling of the can	1.00000 Item(s)	0.00209	
00.81%	market for electricity, low voltage | electricit...	0.02347 MJ	0.00166	0.00166
00.21%	market for refrigerator | refrigerator | Cutoff,...	1.57000E-6 Ite...	0.00043	0.00043

Inventory results | Impact analysis | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks

Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

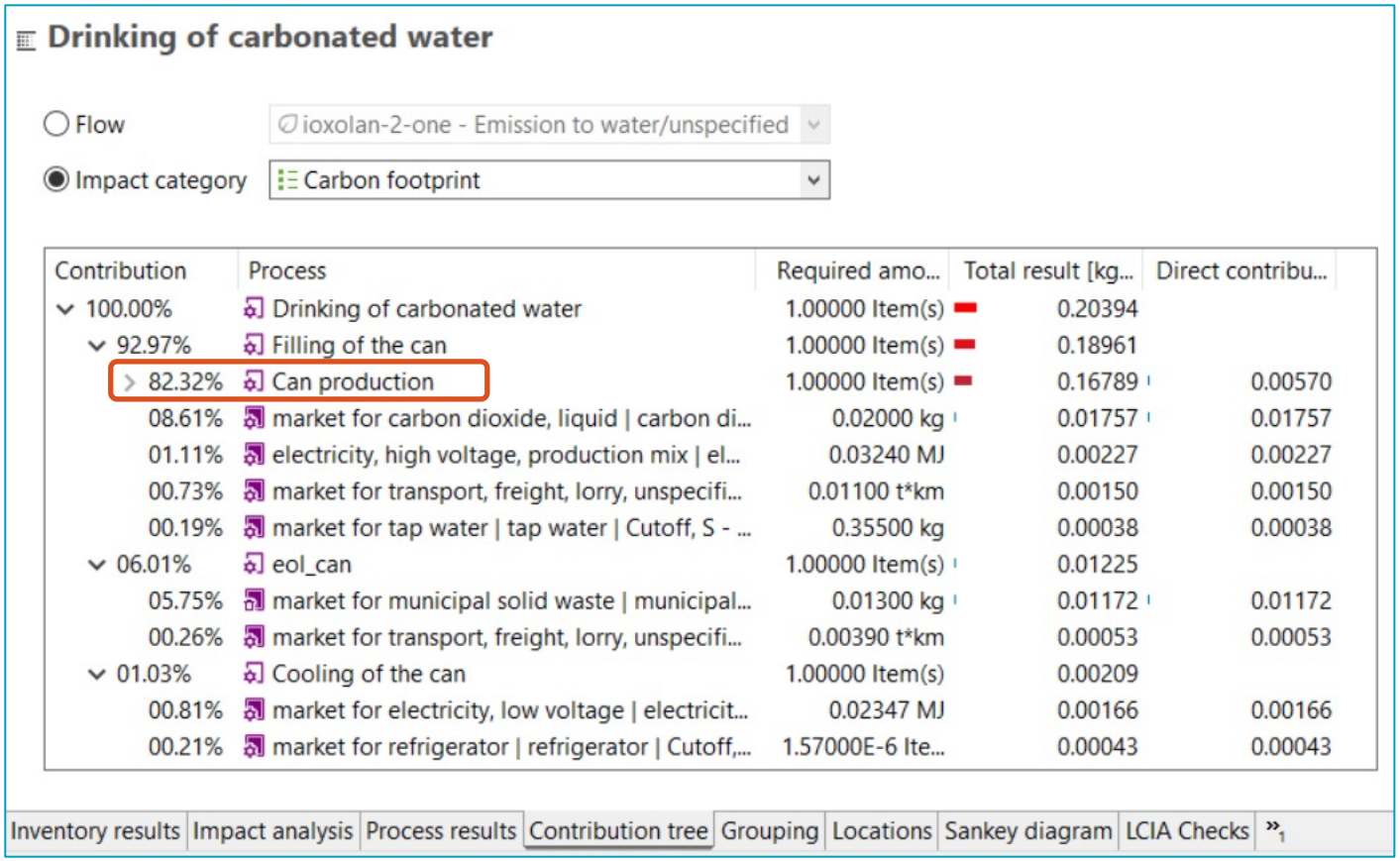
- At the first modelling level (unit process feeding the reference flows)?



Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

- At successive levels (upstream intermediate flows)?

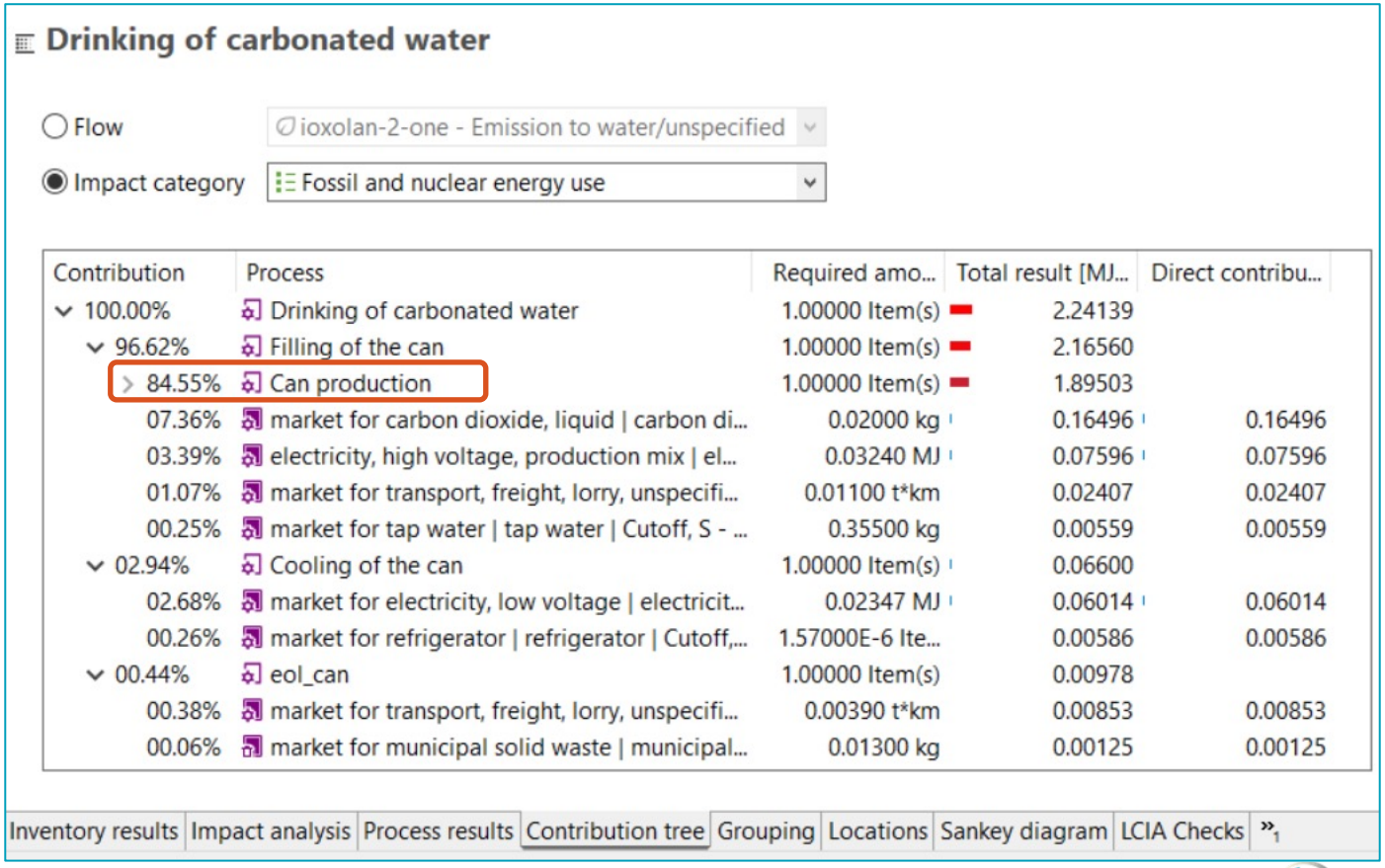


CIRAIG

Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

- At successive levels (upstream intermediate flows)?



Drinking of carbonated water

Flow: ioxolan-2-one - Emission to water/unspecified

Impact category: Fossil and nuclear energy use

Contribution	Process	Required amo...	Total result [MJ...	Direct contribu...
100.00%	Drinking of carbonated water	1.00000 Item(s)	2.24139	
96.62%	Filling of the can	1.00000 Item(s)	2.16560	
84.55%	Can production	1.00000 Item(s)	1.89503	
07.36%	market for carbon dioxide, liquid | carbon di...	0.02000 kg	0.16496	0.16496
03.39%	electricity, high voltage, production mix | el...	0.03240 MJ	0.07596	0.07596
01.07%	market for transport, freight, lorry, unspecifi...	0.01100 t*km	0.02407	0.02407
00.25%	market for tap water | tap water | Cutoff, S - ...	0.35500 kg	0.00559	0.00559
02.94%	Cooling of the can	1.00000 Item(s)	0.06600	
02.68%	market for electricity, low voltage | electricit...	0.02347 MJ	0.06014	0.06014
00.26%	market for refrigerator | refrigerator | Cutoff,...	1.57000E-6 Ite...	0.00586	0.00586
00.44%	eol_can	1.00000 Item(s)	0.00978	
00.38%	market for transport, freight, lorry, unspecifi...	0.00390 t*km	0.00853	0.00853
00.06%	market for municipal solid waste | municipal...	0.01300 kg	0.00125	0.00125

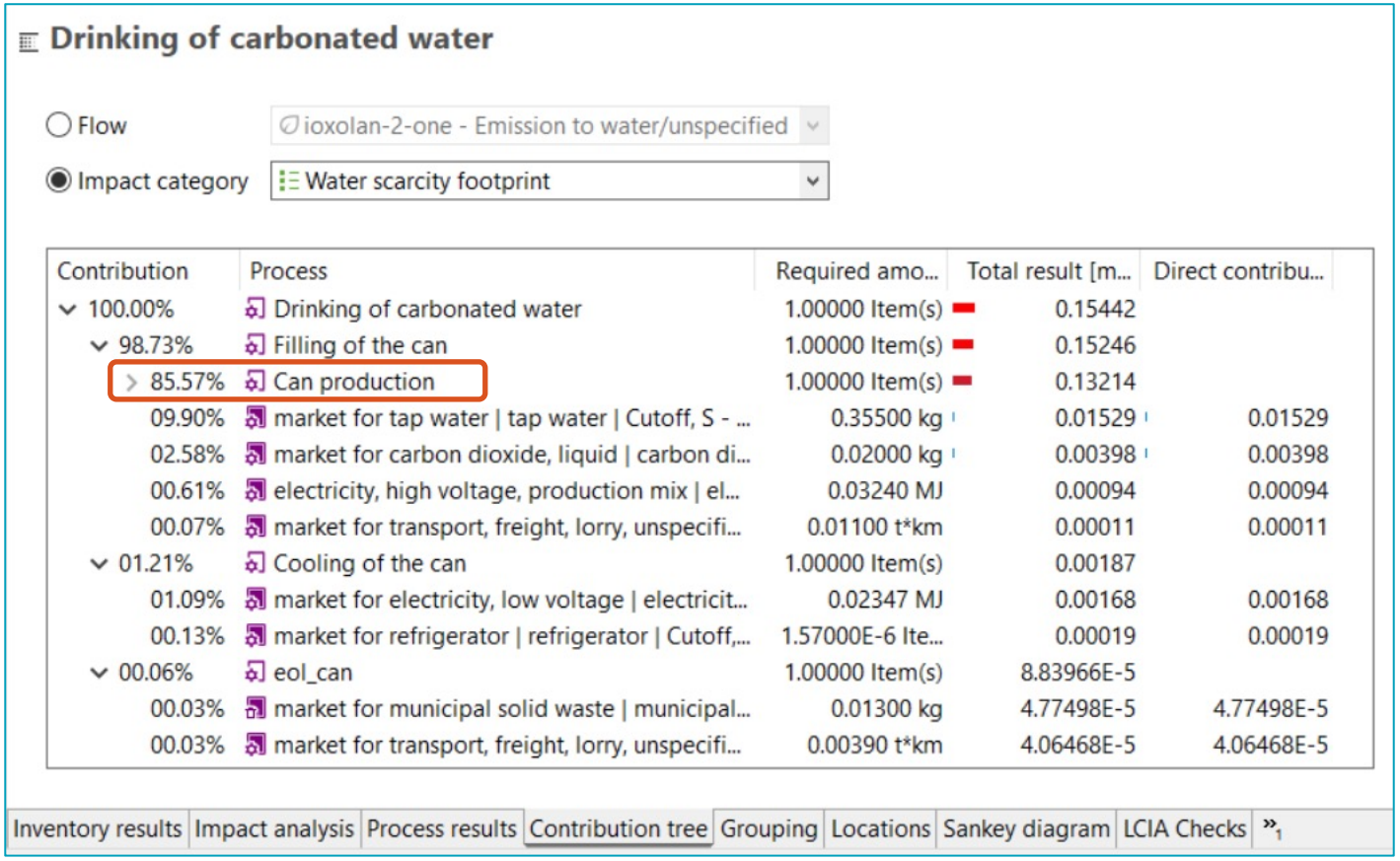
Inventory results | Impact analysis | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks

CIRAIG

Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

- At successive levels (upstream intermediate flows)?

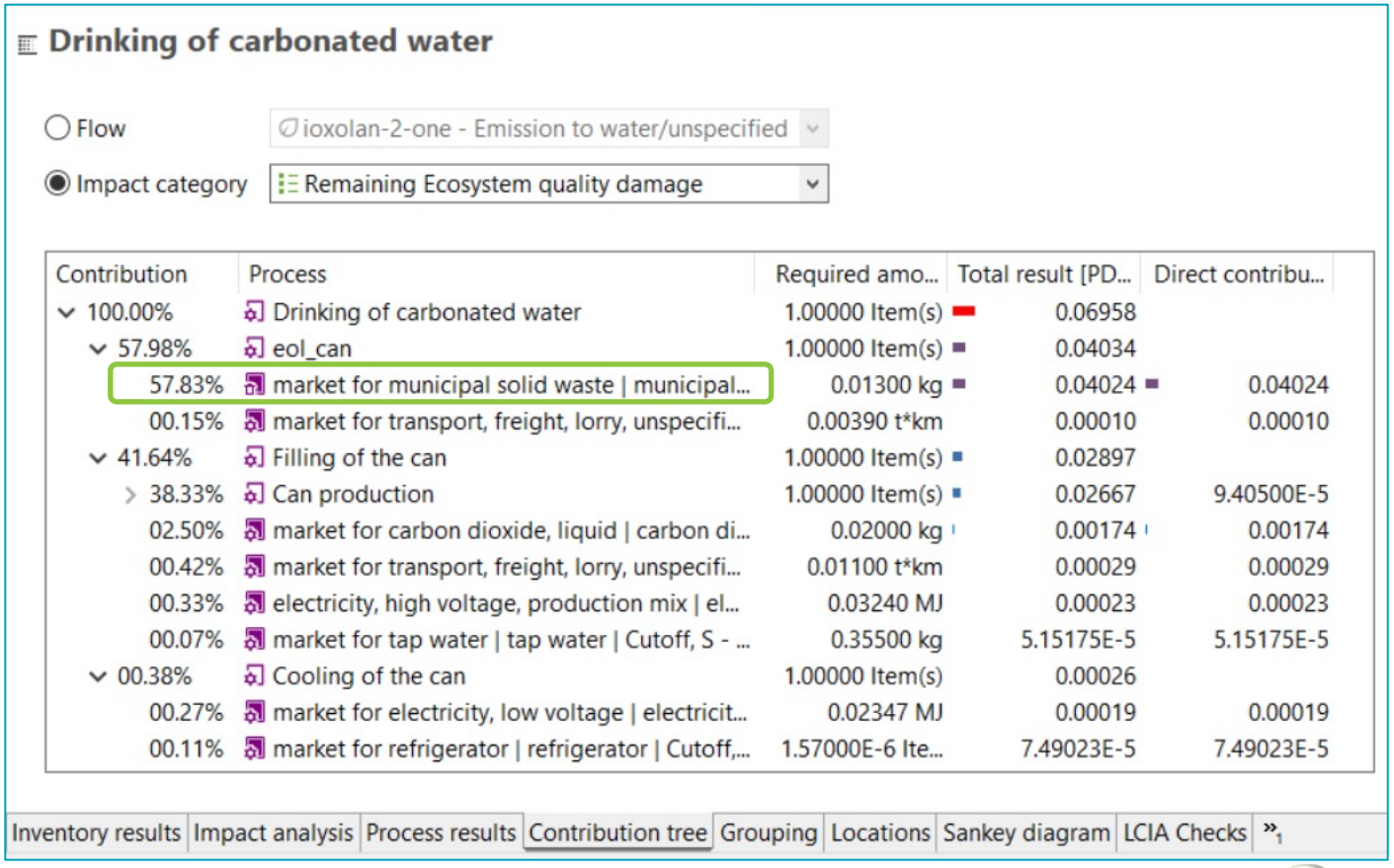


CIRAIG

Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

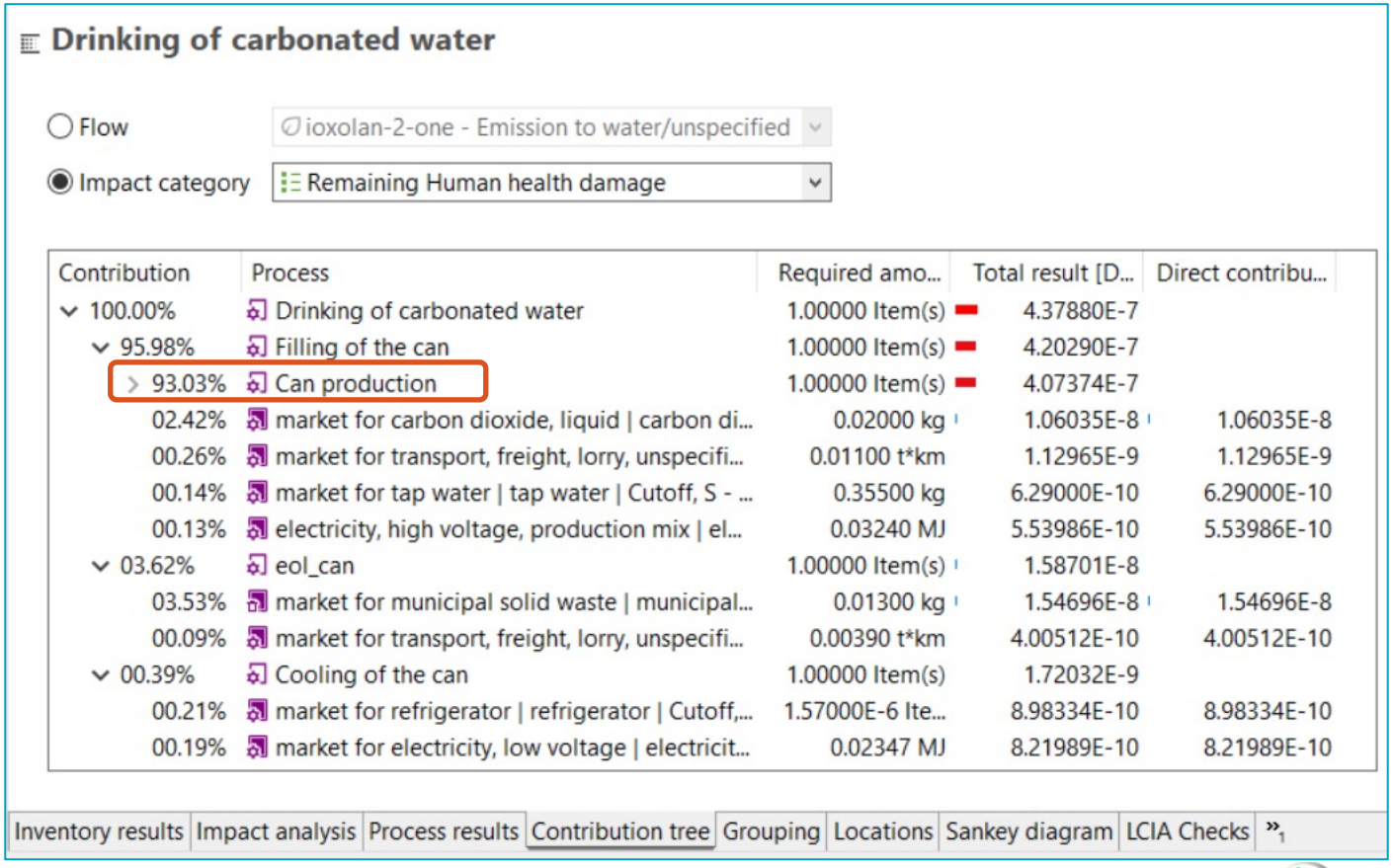
- At successive levels (upstream intermediate flows)?



Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

- At successive levels (upstream intermediate flows)?

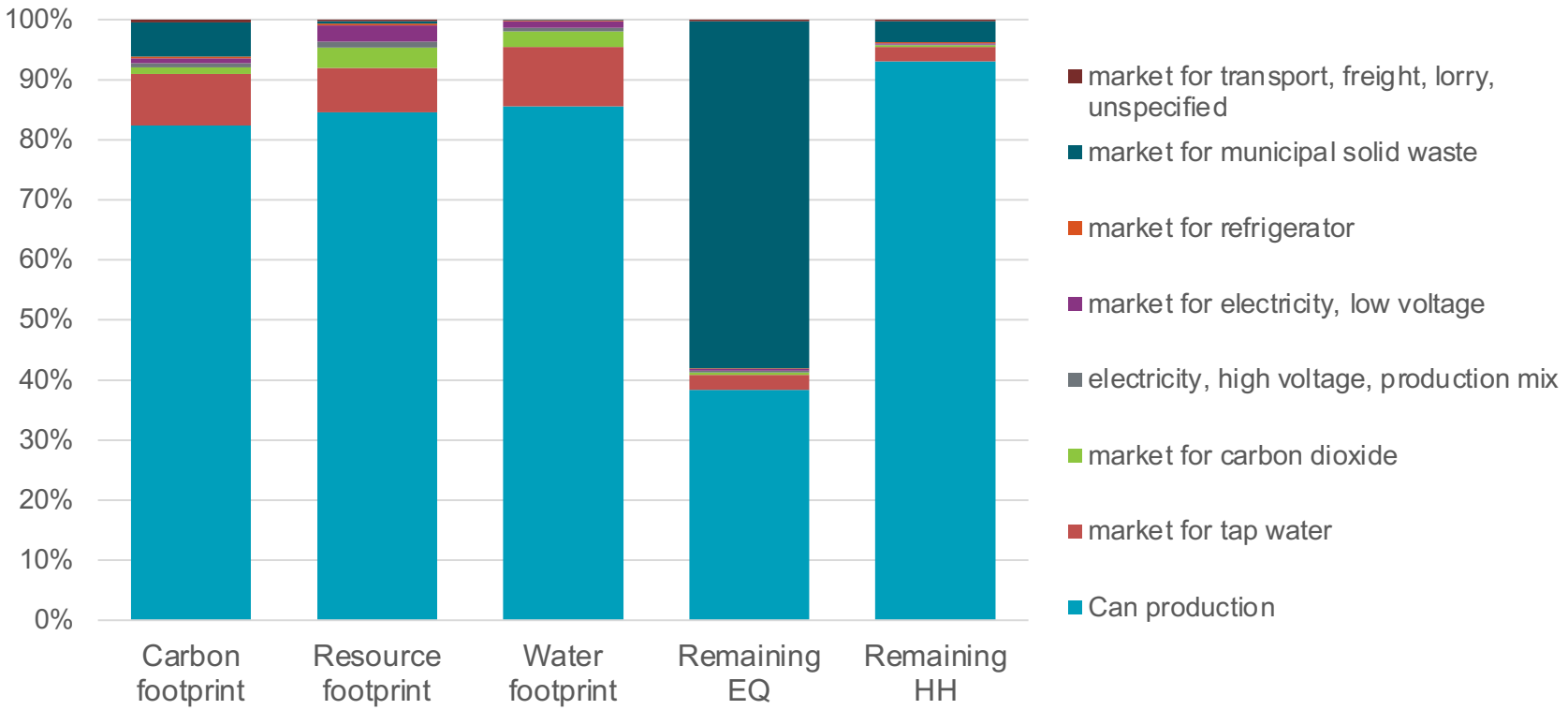


CIRAIG

Question 3

3.1 **Contribution analysis per process** – Which unit process of the reference scenario are the most contributing to the 5 impact categories:

- At successive levels (upstream intermediate flows)?



CIRAIG

Question 3

3.2 **Contribution analysis per elementary flow** to the 5 impact categories of the reference scenario.

Drinking of carbonated water

Impact analysis: IMPACT World+ Footprint v2.0.1

Sub-group by: (•) Flows ( ) Processes | Don't show < 1 %

Name	Category	Inventory result	Characterization factor	Impact assessment result
Fossil and nuclear energy use	IMPACT World+ Footprint v2.0.1			2.24139 MJ deprived
Carbon footprint	IMPACT World+ Footprint v2.0.1			0.20394 kg CO2 eq (short)
Carbon dioxide, fossil	Elementary flows/Emission to air/low po...	0.09594 kg	1.00000 kg CO2 eq (sh...	0.09594 kg CO2 eq (short)
Carbon dioxide, fossil	Elementary flows/Emission to air/high p...	0.04138 kg	1.00000 kg CO2 eq (sh...	0.04138 kg CO2 eq (short)
Carbon dioxide, fossil	Elementary flows/Emission to air/unspec...	0.03163 kg	1.00000 kg CO2 eq (sh...	0.03163 kg CO2 eq (short)
Methane, non-fossil	Elementary flows/Emission to air/low po...	0.00036 kg	27.00000 kg CO2 eq (s...	
Methane, fossil	Elementary flows/Emission to air/low po...	0.00028 kg	29.80000 kg CO2 eq (s...	
Methane, fossil	Elementary flows/Emission to air/high p...	0.00021 kg	29.80000 kg CO2 eq (s...	0.00632 kg CO2 eq (short)
Methane, tetrafluoro-, R-14	Elementary flows/Emission to air/unspec...	4.72178E-		
Methane, fossil	Elementary flows/Emission to air/unspec...	7.23848E-		
Water scarcity footprint	IMPACT World+ Footprint v2.0.1			
Remaining Ecosystem quality damage	IMPACT World+ Footprint v2.0.1			0.06958 PDF.m2.yr
Remaining Human health damage	IMPACT World+ Footprint v2.0.1			4.37880E-7 DALY

0.169 kg CO2 eq

From hand calcs:
Carbon dioxide, fossil: 0.169 kg CO2 eq

General information | Inventory results | Impact analysis | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks

CIRAIG

Question 3

3.2 **Contribution analysis per elementary flow** to the 5 impact categories of the reference scenario.

Drinking of carbonated water

Impact analysis: IMPACT World+ Footprint v2.0.1

Sub-group by: (•) Flows ( ) Processes | Don't show < 1 %

Name	Category	Inventory result	Characterization factor	Impact assessment result
Fossil and nuclear energy use	IMPACT World+ Footprint v2.0.1			2.24139 MJ deprived
Coal, hard, unspecified, in ground	Elementary flows/Resource/in ground	0.03830 kg	19.10000 MJ deprived/...	0.73150 MJ deprived
Gas, natural, in ground	Elementary flows/Resource/in ground	0.01307 m3	40.30000 MJ deprived/...	0.52676 MJ deprived
Oil, crude, in ground	Elementary flows/Resource/in ground	0.00808 kg	45.80000 MJ deprived/...	0.37025 MJ deprived
Coal, brown, in ground	Elementary flows/Resource/in ground	0.03353 kg	9.90000 MJ deprived/kg	0.33193 MJ deprived
Uranium, in ground	Elementary flows/Resource/in ground	4.79796E-7 kg	5.60000E5 MJ deprived...	0.26869 MJ deprived
Carbon footprint	IMPACT World+ Footprint v2.0.1			0.20394 kg CO2 eq (short)
Water scarcity footprint	IMPACT World+ Footprint v2.0.1			
Remaining Ecosystem quality damage	IMPACT World+ Footprint v2.0.1			
Remaining Human health damage	IMPACT World+ Footprint v2.0.1			

From hand calcs:
Coal, hard, unspecified, in ground: 0.732 MJ deprived

General information | Inventory results | Impact analysis | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks

CIRAIG

Question 3

3.2 **Contribution analysis per elementary flow** to the 5 impact categories of the reference scenario.

Drinking of carbonated water

Impact analysis: IMPACT World+ Footprint v2.0.1

Sub-group by: (•) Flows ( ) Processes | Don't show < 1 %

Name	Category	Inventory result	Characterization factor	Impact assessment res...
Fossil and nuclear energy use	IMPACT World+ Footprint v2.0.1			2.24139 MJ deprived
Carbon footprint	IMPACT World+ Footprint v2.0.1			0.20394 kg CO2 eq (sh...
Water scarcity footprint	IMPACT World+ Footprint v2.0.1			0.15442 m3 world-eq
Water, turbine use, unspecified natural orig	Elementary flows/Resource/in water	2.12812 m3	42.95353 m3 world-eq...	91.41045 m3 world-...
Water, cooling, unspecified natural origin	Elementary flows/Resource/in water	0.00639 m3	42.95353 m3 world-eq...	0.27455 m3 world-eq
Water, river	Elementary flows/Resource/in water	0.00078 m3	42.95353 m3 world-eq...	0.03341 m3 world-eq
Water, well, in ground	Elementary flows/Resource/in water	0.00046 m3	42.95353 m3 world-eq...	[illegible]
Water, unspecified natural origin	Elementary flows/Resource/in water	0.00031 m3	42.95353 m3 world-eq...	
Water, lake	Elementary flows/Resource/in water	8.04638E-5 m3	42.95353 m3 world-eq...	0.00346 m3 world-eq
Water	Elementary flows/Emission to water/surf...	0.00032 m3	-42.95353 m3 world-e...	-0.01361 m3 world-eq
Water	Elementary flows/Emission to water/gro...	0.00043 m3	-42.95353 m3 world-e...	-0.01840 m3 world-eq
Water	Elementary flows/Emission to water/uns...	2.13181 m3	-42.95353 m3 world-e...	-91.56888 m3 world-...
Remaining Ecosystem quality damage	IMPACT World+ Footprint v2.0.1			[illegible]yr
Remaining Human health damage	IMPACT World+ Footprint v2.0.1			[illegible]LY

Sum = 0.151

From hand calcs:
Water: 0.151 m3 world-eq

General information | Inventory results | Impact analysis | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks

CIRAIG

Question 3

3.2 **Contribution analysis per elementary flow** to the 5 impact categories of the reference scenario.

Drinking of carbonated water

Impact analysis: IMPACT World+ Footprint v2.0.1

Sub-group by: (•) Flows ( ) Processes | Don't show < 1 %

Name	Category	Inventory result	Characterization factor	Impact assessment res...
Fossil and nuclear energy use	IMPACT World+ Footprint v2.0.1			2.24139 MJ deprived
Carbon footprint	IMPACT World+ Footprint v2.0.1			0.20394 kg CO2 eq (sh...
Water scarcity footprint	IMPACT World+ Footprint v2.0.1			0.15442 m3 world-eq
Remaining Ecosystem quality damage	IMPACT World+ Footprint v2.0.1			0.06958 PDF.m2.yr
Aluminium	Elementary flows/Emission to soil/indust...	3.03573E-5 kg	1078.59993 PDF.m2.yr/...	0.03274 PDF.m2.yr
Transformation, to lake, artificial	Elementary flows/Resource/land	0.00015 m2	37.20313 PDF.m2.yr/m2	0.00541 PDF.m2.yr
Transformation, to mineral extraction site	Elementary flows/Resource/land	2.91719E-5 m2	168	
Sulfur dioxide	Elementary flows/Emission to air/unspec...	0.00029 kg	1(	
Sulfur dioxide	Elementary flows/Emission to air/low po...	0.00026 kg	1(	
Iron	Elementary flows/Emission to soil/indust...	4.12311E-5 kg	93.67335 PDF.m2.yr/kg	0.00386 PDF.m2.yr
Copper	Elementary flows/Emission to soil/indust...	1.36985E-6 kg	2703.20468 PDF.m2.yr/...	0.00370 PDF.m2.yr
Sulfur dioxide	Elementary flows/Emission to air/high p...	0.00020 kg	16.64933 PDF.m2.yr/kg	0.00334 PDF.m2.yr
Occupation, lake, artificial	Elementary flows/Resource/land	0.01476 m2*a	0.18583 PDF.m2.yr/m2*a	0.00274 PDF.m2.yr
Aluminium	Elementary flows/Emission to soil/unspe...	2.32551E-6 kg	1078.59993 PDF.m2.yr/...	0.00251 PDF.m2.yr
Transformation, to forest, intensive	Elementary flows/Resource/land	6.39546E-5 m2	37.34470 PDF.m2.yr/m2	0.00239 PDF.m2.yr
Transformation, to annual crop	Elementary flows/Resource/land	1.01631E-5 m2	159.16667 PDF.m2.yr/m2	0.00162 PDF.m2.yr

From hand calcs:
Aluminium: 0.0.0327 PDF.m2.yr

General information | Inventory results | Impact analysis | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks

CIRAIG

Question 3

3.2 **Contribution analysis per elementary flow** to the 5 impact categories of the reference scenario.

Drinking of carbonated water

Impact analysis: IMPACT World+ Footprint v2.0.1

Sub-group by: (•) Flows ( ) Processes | Don't show < 1 %

Name	Category	Inventory result	Characterization factor	Impact assessment res...
Fossil and nuclear energy use	IMPACT World+ Footprint v2.0.1			2.24139 MJ deprived
Carbon footprint	IMPACT World+ Footprint v2.0.1			0.20394 kg CO2 eq (sh...
Water scarcity footprint	IMPACT World+ Footprint v2.0.1			0.15442 m3 world-eq
Remaining Ecosystem quality damage	IMPACT World+ Footprint v2.0.1			0.06958 PDF.m2.yr
Remaining Human health damage	IMPACT World+ Footprint v2.0.1			4.37880E-7 DALY
Chromium VI	Elementary flows/Emission to water/surf...	1.46479E-6 kg	0.11391 DALY/kg	1.66854E-7 DALY
Arsenic, ion	Elementary flows/Emission to water/surf...	9.82446E-7 kg		
Particulates, < 2.5 um	Elementary flows/Emission to air/low po...	0.00026 kg		
Particulates, < 2.5 um	Elementary flows/Emission to air/high p...	2.23837E-5 kg		
Particulates, < 2.5 um	Elementary flows/Emission to air/unspec...	2.33810E-5 kg	0.00120 DALY/kg	2.80571E-8 DALY
Sulfur dioxide	Elementary flows/Emission to air/unspec...	0.00029 kg	6.90030E-5 DALY/kg	1.99368E-8 DALY
Sulfur dioxide	Elementary flows/Emission to air/low po...	0.00026 kg	6.20030E-5 DALY/kg	1.63501E-8 DALY
Sulfur dioxide	Elementary flows/Emission to air/high p...	0.00020 kg	7.70030E-5 DALY/kg	1.54700E-8 DALY
Dioxins, measured as 2,3,7,8-tetrachlorodil	Elementary flows/Emission to air/unspec...	1.69719E-11 kg	391.02713 DALY/kg	6.63649E-9 DALY

From hand calcs:
Chromium VI: 1.67E-07 DALY

General information | Inventory results | Impact analysis | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks

CIRAIG

Question 4

4 We want to compare the impact profiles of three aluminum can scenarios (produced in the US, in China and in Québec) by applying the footprint profile of the IMPACT World+ method. To be done via Excel graphs:

a) Represent the results of the comparison with a figure presenting the impact profile via an internal normalization (100% being the scenario with the highest impact score per category).

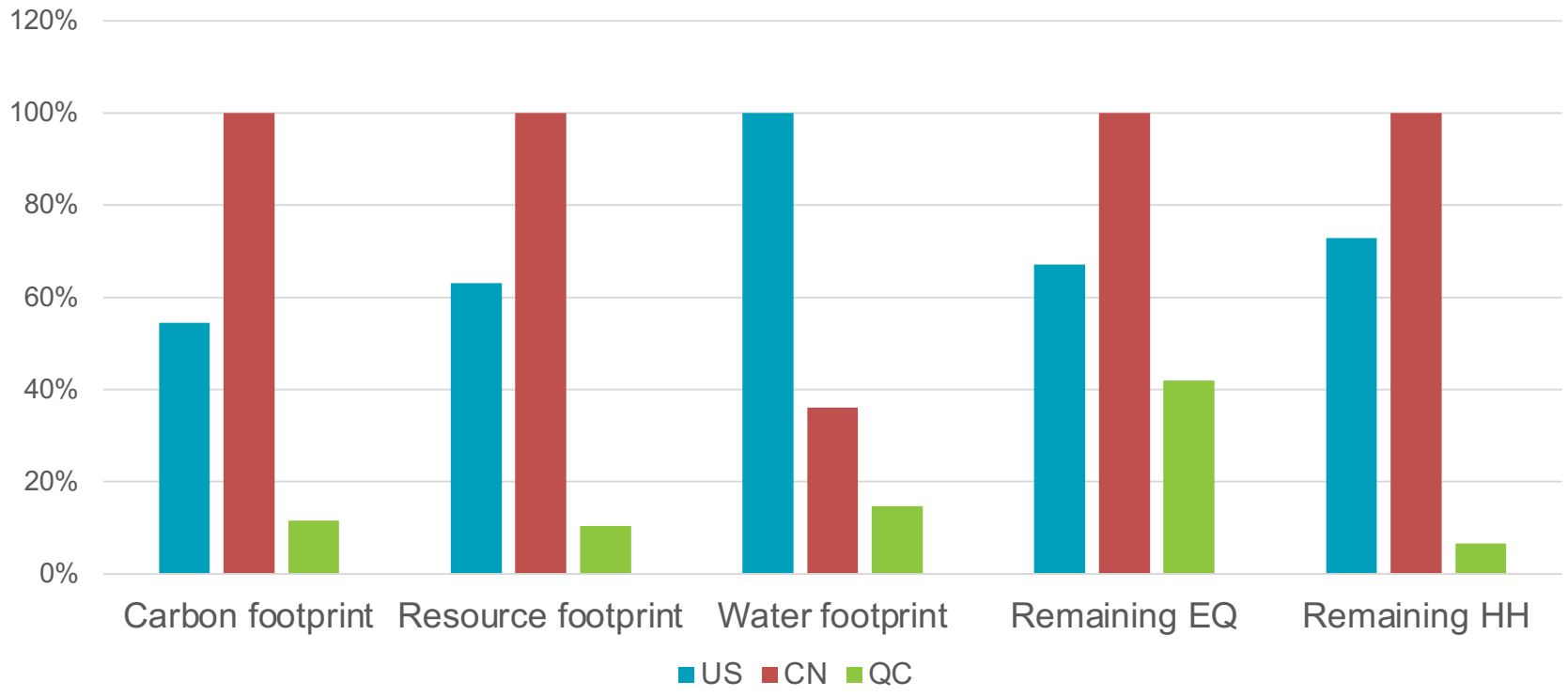
b) Propose a contribution analysis per process at the first level (i.e., feeding reference flows) and second level (i.e., feeding upstream intermediary flows) on the same graph.

c) For elementary processes being important contributors, identify the main elementary flows.

Question 4

3.2 Compare the impact profiles of three aluminum can scenarios (produced in the US, in China and in Québec)

a) Represent the results of the comparison with a figure presenting the impact profile via an internal normalization

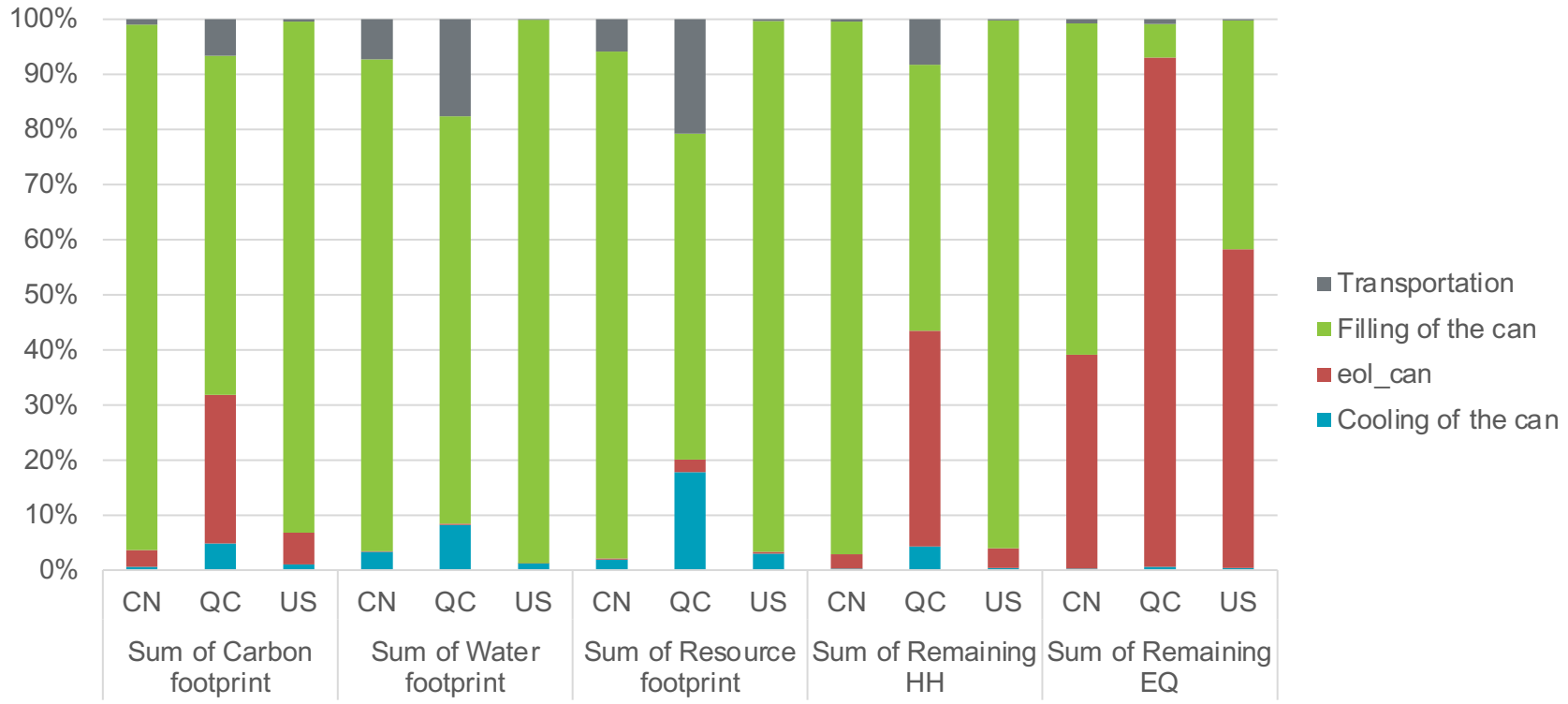


CIRAIG

Question 4

3.2 Compare the impact profiles of three aluminum can scenarios (produced in the US, in China and in Québec)

b) Propose a contribution analysis per process at the first level (i.e., feeding reference flows) and second level (i.e., feeding upstream intermediary flows) on the same graph.

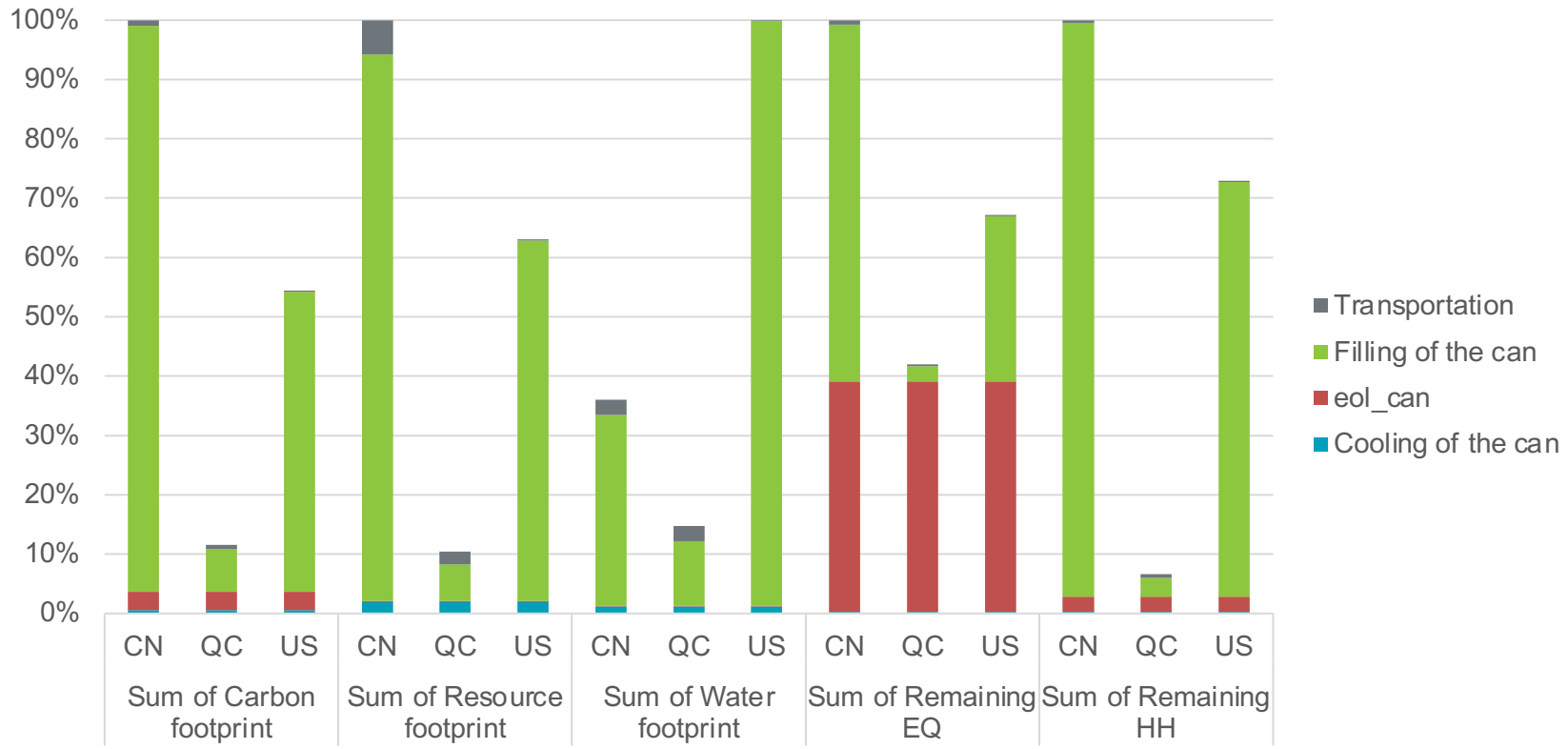


CIRAIG

Question 4

3.2 Compare the impact profiles of three aluminum can scenarios (produced in the US, in China and in Québec)

b) Propose a contribution analysis per process at the first level (i.e., feeding reference flows) and second level (i.e., feeding upstream intermediary flows) on the same graph.



CIRAIG

Question 4

3.2 Compare the impact profiles of three aluminum can scenarios (produced in the US, in China and in Québec)

c) For elementary processes being important contributors, identify the main elementary flows

Drinking of carbonated water (CN Lab2)

Impact analysis: IMPACT World+ Footprint v2.0.1

Sub-group by: (•) Flows ( ) Processes | Don't show < 29 %

Name	Category	Inventory result	Characterization factor	Impact assessment result
Fossil and nuclear energy use	IMPACT World+ Footprint v2.0.1			3.55356 MJ deprived
Coal, hard, unspecified, in ground	Elementary flows/Resource/in ground	0.13084 kg	19.10000 MJ deprived/kg	2.49906 MJ deprived
Carbon footprint	IMPACT World+ Footprint v2.0.1			0.37470 kg CO2 eq (short)
Carbon dioxide, fossil	Elementary flows/Emission to air/low po...	0.21794 kg	1.00000 kg CO2 eq (short)/...	0.21794 kg CO2 eq (short)
Remaining Ecosystem quality damage	IMPACT World+ Footprint v2.0.1			0.10360 PDF.m2.yr
Aluminium	Elementary flows/Emission to soil/indust...	3.04113E-5 kg	1078.59993 PDF.m2.yr/kg	0.03280 PDF.m2.yr
Water scarcity footprint	IMPACT World+ Footprint v2.0.1			0.05565 m3 world-eq
Water, turbine use, unspecified natural orig	Elementary flows/Resource/in water	1.23916 m3	42.95353 m3 world-eq/m3	53.22617 m3 world-eq
Water, cooling, unspecified natural origin	Elementary flows/Resource/in water	0.01287 m3	42.95353 m3 world-eq/m3	0.55262 m3 world-eq
Water, river	Elementary flows/Resource/in water	0.00112 m3	42.95353 m3 world-eq/m3	0.04803 m3 world-eq
Water, well, in ground	Elementary flows/Resource/in water	0.00064 m3	42.95353 m3 world-eq/m3	0.02732 m3 world-eq
Water	Elementary flows/Emission to water/gro...	0.00048 m3	-42.95353 m3 world-eq/m3	-0.02046 m3 world-eq
Water	Elementary flows/Emission to water/uns...	1.25210 m3	-42.95353 m3 world-eq/m3	-53.78202 m3 world-eq
Remaining Human health damage	IMPACT World+ Footprint v2.0.1			6.00524E-7 DALY
Chromium VI	Elementary flows/Emission to water/surf...	1.57102E-6 kg	0.11391 DALY/kg	1.78954E-7 DALY

General information | Inventory results | Impact analysis | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks

Question 4

3.2 Compare the impact profiles of three aluminum can scenarios (produced in the US, in China and in Québec)

c) For elementary processes being important contributors, identify the main elementary flows

Drinking of carbonated water (QC Lab2)

Impact analysis: IMPACT World+ Footprint v2.0.1

Sub-group by: (•) Flows ( ) Processes | Don't show < 29 %

Name	Category	Inventory result	Characterization factor	Impact assessment res...
Fossil and nuclear energy use	IMPACT World+ Footprint v2.0.1			1.39630 MJ deprived
Coal, hard, unspecified, in ground	Elementary flows/Resource/in ground	0.02368 kg	19.10000 MJ deprived/...	0.45232 MJ deprived
Water scarcity footprint	IMPACT World+ Footprint v2.0.1			0.22746 m3 world-eq
Water, turbine use, unspecified natural orig	Elementary flows/Resource/in water	1.94832 m3	42.95353 m3 world-eq...	83.68741 m3 world-...
Water, cooling, unspecified natural origin	Elementary flows/Resource/in water	0.00332 m3	42.95353 m3 world-eq...	0.14241 m3 world-eq
Water	Elementary flows/Emission to water/uns...	1.94665 m3	-42.95353 m3 world-e...	-83.61534 m3 world-...
Carbon footprint	IMPACT World+ Footprint v2.0.1			0.13740 kg CO2 eq (sh...
Carbon dioxide, fossil	Elementary flows/Emission to air/high p...	0.04234 kg	1.00000 kg CO2 eq (sh...	0.04234 kg CO2 eq (...
Remaining Ecosystem quality damage	IMPACT World+ Footprint v2.0.1			0.06878 PDF.m2.yr
Aluminium	Elementary flows/Emission to soil/indust...	3.03302E-5 kg	1078.59993 PDF.m2.yr/...	0.03271 PDF.m2.yr
Remaining Human health damage	IMPACT World+ Footprint v2.0.1			3.77843E-7 DALY
Chromium VI	Elementary flows/Emission to water/surf...	1.45844E-6 kg	0.11391 DALY/kg	1.66131E-7 DALY

General information | Inventory results | Impact analysis | Process results | Contribution tree | Grouping | Locations | Sankey diagram | LCIA Checks

Question 5 (Bonus)

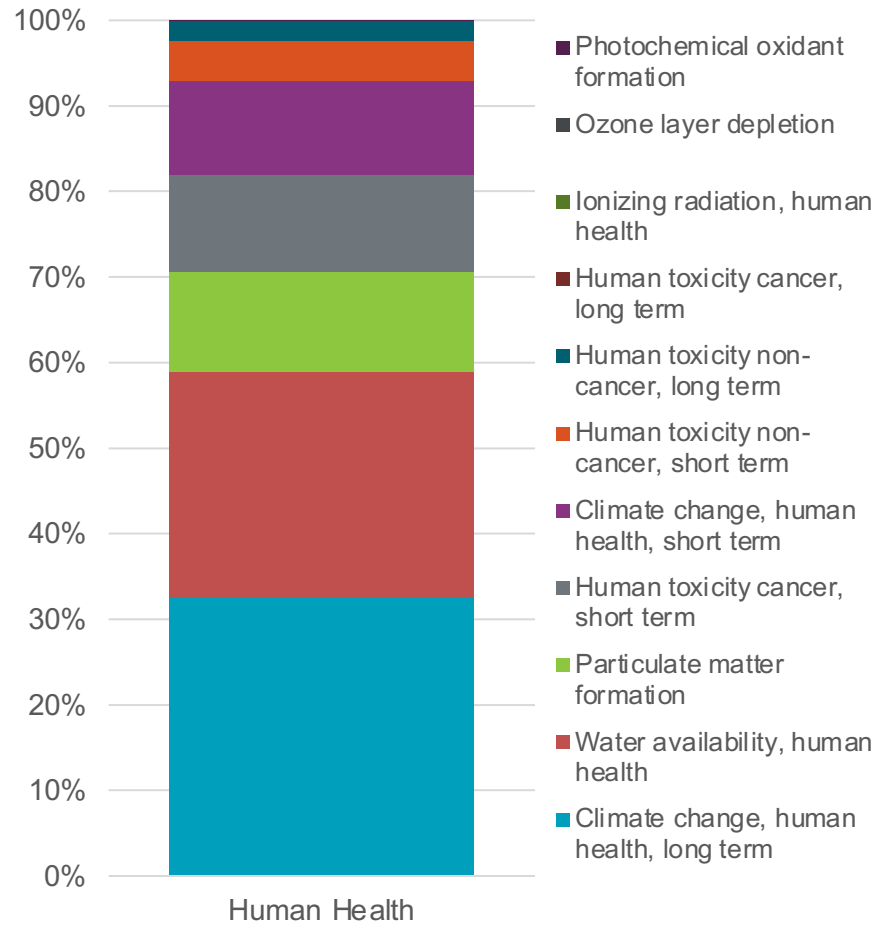
5.1 Analyze the contribution per environmental problem to the areas of protection HH and EQ.

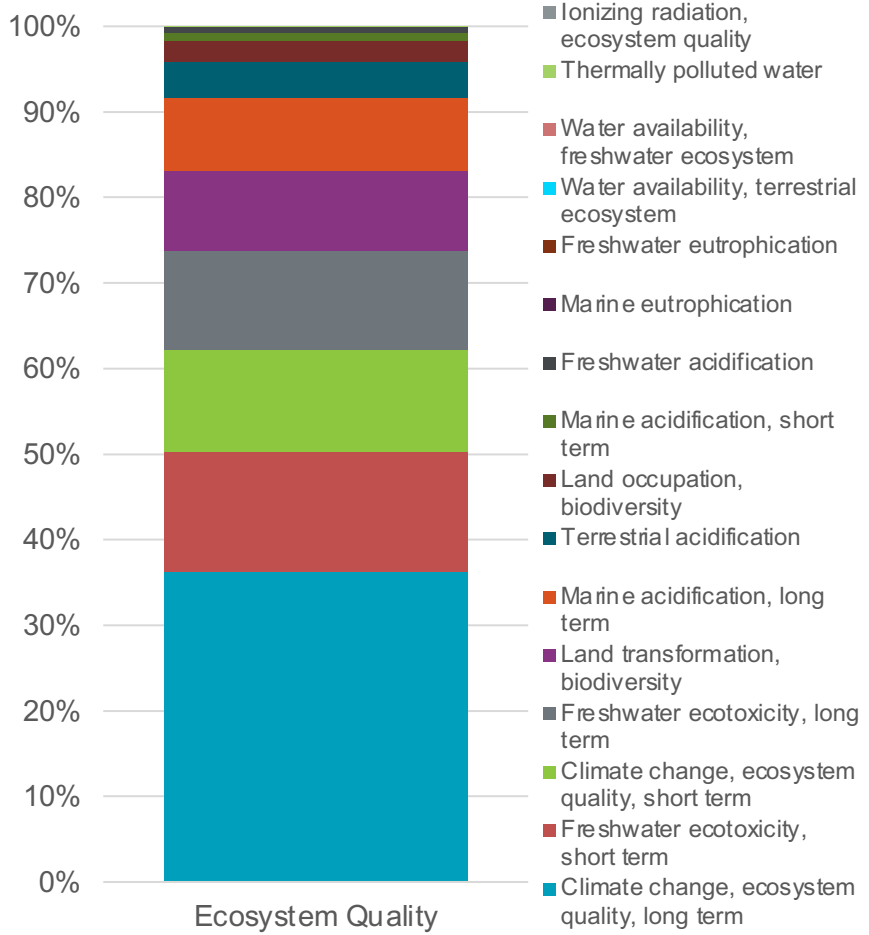
Compute the scores to damage of the expert version of IMPACT World+ for the same reference product system with OpenLCA.

Which environmental problem is contributing the more to the total HH and EQ, respectively? What is the link that we can establish with the elementary flow contribution analysis?

Question 5 (Bonus)

5.1 Analyze the contribution per environmental problem to the areas of protection HH and EQ.





CIRAIG

Question 5 (Bonus)

5.2) Compute the normalized impact scores for the HH and EQ categories. How to interpret the units of the normalized scores? Can we add up the normalized scores (environmental impact points) obtained for HH and EQ? If yes, in which conditions?

5.3) Compute a unique score with:

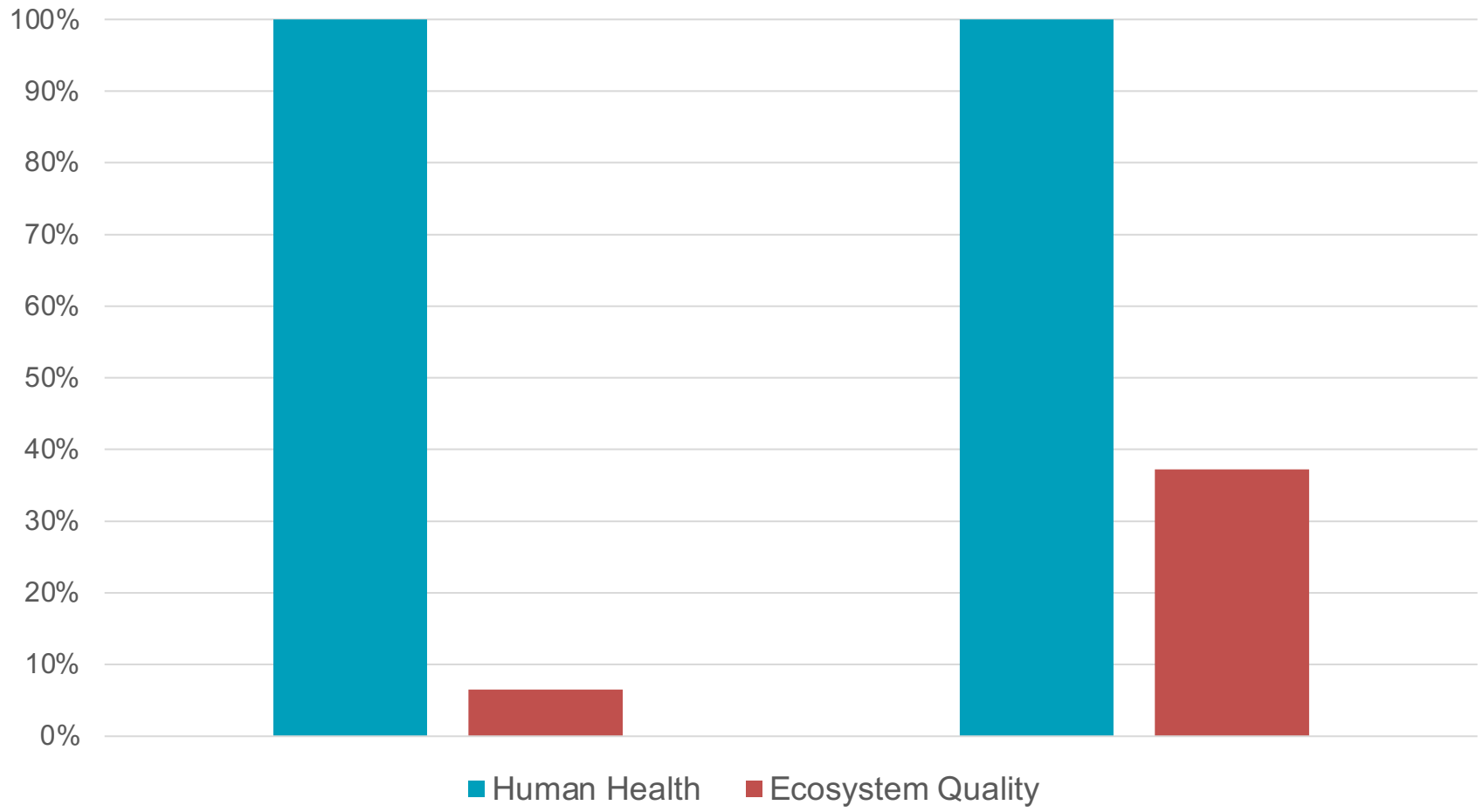
1. an explicit egalitarian weighting of normalized impact scores to the areas of protection (i.e., HH, EQ)

2. the monetary weighting factors proposed by IMPACT World+:
   - HH = 74000€/DALY,
   - EQ = 0.14€/PDF_m2_yr

How to interpret the results from these two weighting approaches?

Question 5 (Bonus)

5.2 & 5.3 Compute normalized impact scores

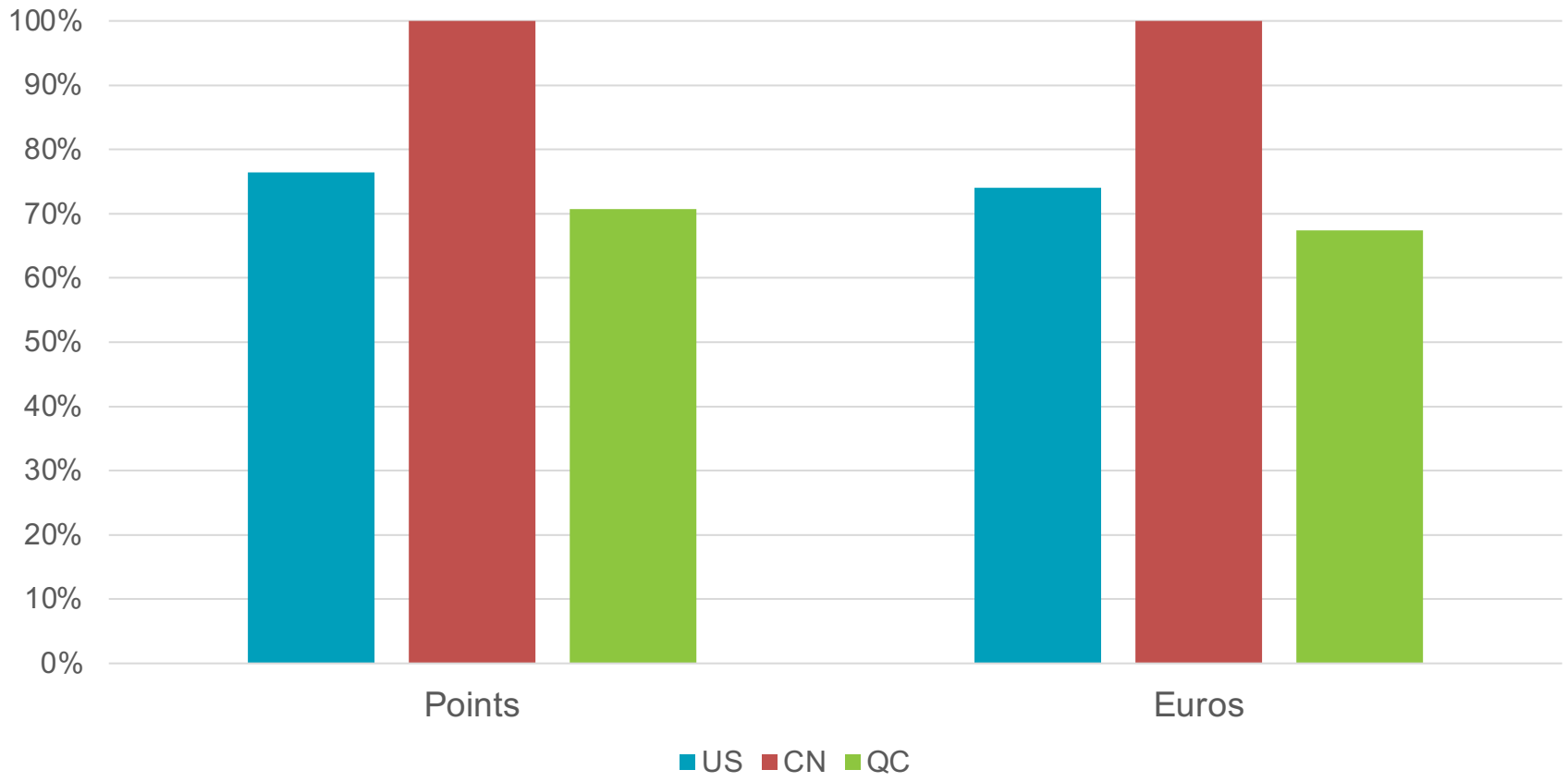


CIRAIG

Question 5 (Bonus)

5.2 & 5.3 Compute normalized impact scores

*Note: the exercise only asks you to compute the normalized scores for the reference (US) system. This is only shown here to show how simplified our comparison becomes when we apply normalization



CIRAIG