TP2 – Define the Goal & Scope (part 2)

--- PART 1 ---

Exercice 1 - Goal and Scope of the study

Context : XLERATOR hand-dryer

The company *Excel Dryer, Inc.* produces and sells electrical hand-dryers in the United-States. XLERATOR is designed for public spaces. The energy-efficiency of XLERATOR is excellent and the company would like to show its clients the environmental performances of its product all along its life cycle. The company would like to position its product compared to other hand-drying alternatives to be used in public spaces (classic electric hand-dryer and paper towels). Finally, the company would like to know the influence of several key variables and features on the environmental performances (use intensity, electricity source, use of recycled material, etc.)


Three alternatives for hand-drying: XLERATOR (left), CLASSIC electric hand-dryer (middle) and PAPER towels (right)

Question 1 : Function (Fx), Functional Unit (FU), Reference flow (RF) and Key Parameter (KP)

1.1. Identify a shared function for the three product systems.
1.2. Are the three product systems functionally equivalent?
1.3. Define a functional unit to use to compare the three product systems.
1.4. Draw the “cradle-to-grave” process trees for each one of the three product systems
1.5. For each product system, identify the aggregated (cradle-to-gate) and disaggregated (gate-to-gate) processes
1.6. Recall the definition of a reference flow. Identify the reference flows associated with each of the three product systems.
1.7. Recall the definition of a set of key parameters. Identify the key parameters you need to calculate the following flows:1) Hand dryer and electricity for the electric hand dryer and 2) paper, distributor, bin bags and bin for the PAPER system

Question 2 : Calculation of the RF – Electric hand-dryers

2.1 From the following information, calculate the "electricity" and "hand dryer" flows of the XLERATOR and CLASSIC product systems (be sure to scale the flows to the functional unit!) :

- Both hand-dryers are used 500 times per week on average (500 hands pairs) and have a 10 years lifetime.
- The use phase of both hand-dryers is described in the following table:

	XLERATOR	CLASSIC
Power (W)	1 500	2 300
Use time (s)	12	30
Shutdown time (s)	1,5	1,5
Average power during shutdown (W)	750	1150

2.2 What happens to the reference flows when the average use time is cut by half? Calculate for XLERATOR only.
2.3 What happens to the reference flows when the number of uses is cut by half? Calculate for XLERATOR only.

Question 3 : Calculation of the RF and other intermediary flows - Paper towels system

3.1 Use the following data to calculate the reference flows for the paper towels (PAPER) product system : Paper, Distributor, Distributor in EoL, Distributor in maintenance, EoL paper towel

- On average, 2 sheets are used to dry a pair of hands.
- The surface of a sheet is 0,073 m^2.
- The paper density is 28,17 g/m^2.
- The paper distributor has a 10 years lifetime.
- On average, 500 pairs of hands are washed and dryers per week (same bathroom than the electric hand dryer)
- Garbage bags are changed daily.
- The garbage bin has a 10 years lifetime.
- Maintenance occurs every 24 weeks
- The paper landfill is located 20km from the place of use.

3.2 Calculate the value of the intermediate flows involved in the end-of-life process for used towels

--- PART 2---

Exercice 2 – Carbonated water can - part 2

Context: Consumption of 1 cooled carbonated water can

In the previous lab, you performed a simplified LCA of a system of carbonated water cans produced in the United States, focusing on its carbon footprint. The functional unit chosen was: "Consuming 1 x 355mL can of cooled carbonated water in Portland in 2021". As a reminder, you will find the modeled process tree and the results obtained during TP1 in Figures 1 and 2, respectively.

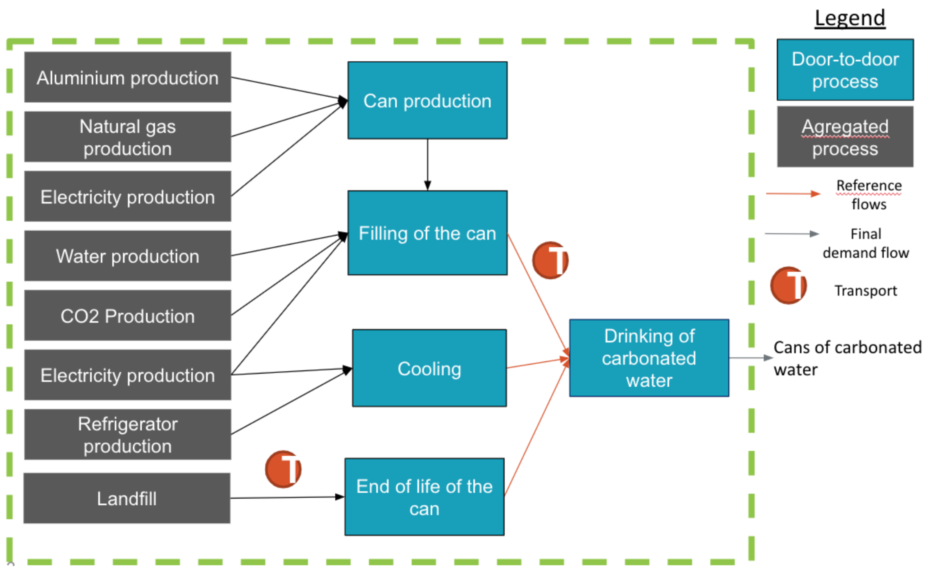

Figure 1: Process tree

PROCESSES	Intermediary flows			Elementary flows CO2 (kg)	CH4 (kg)	Total CO2 CO2e (kg)	Contribution	Total per process CO2e (kg)	Contrib per process
Drinking of carbonated water	Carbonated water can	1	item					7.43E-03	3.65%
	Refrigerated water can	1	item						
	End of life can	1	item						
	Transport	1.10E-02	tkm	1.45E-03	2.01E-04	7.43E-03	3.65%		
Can production	Electricity production	3.00E-02	kWh	6.66E-03	2.13E-05	7.29E-03	3.58%	1.59E-01	78.28%
	Natural gas production	0.003	Nm3	4.71E-04	2.94E-05	1.34E-03	0.66%		
	Aluminium production	1.30E-02	kg	1.38E-01	2.24E-04	1.45E-01	71.24%		
	Elementary flow link to NG combustion			5.70E-03		5.70E-03	2.80%		
Filling	Electricity production	9.00E-03	kWh	2.00E-03	6.39E-06	2.19E-03	1.08%	1.98E-02	9.71%
	Tap water production	3.55E-04	m3	3.48E-04	8.13E-07	3.72E-04	0.18%		
	Pressurized CO2 production	2.00E-02	kg	1.04E-02	2.30E-04	1.72E-02	8.45%		
	Can production	1	item			0.00E+00	0.00%		
Cooling	Electricity production	0.00652	kWh	1.45E-03	4.63E-06	1.58E-03	0.78%	1.93E-03	0.95%
	Fridge production	1.57E-06	frigo	3.01E-04	1.48E-06	3.45E-04	0.17%		
End of life can	Transport	3.90E-03	tkm	5.15E-04	7.14E-05	2.63E-03	1.29%	1.51E-02	7.41%
	Landfill Aluminium	1.30E-02	kg	1.21E-03	3.78E-04	1.24E-02	6.12%		
				1.69E-01	**1.17E-03**	**2.03E-01**	100.00%	**2.035E-01**	**1.00E+00**

Figure 2: carbon footprint results of the can system

This study highlighted the importance of the aluminum can production in the carbon footprint of the system. However, the "aluminum ingot" flow used in the modeling is a generic flow (average value modeled for North America). Given the large contribution of this element to the total carbon footprint of the system, it seems important to analyze the sensitivity of the source of the aluminum to the results. Thus, you want to model the system in which the aluminum would have other origins: Guangdong, China, as well as Quebec.

Supplementary informations :

- 1.02kg of liquid aluminum and 0.067kWh of electricity are required to produce 1kg of aluminum ingot.
- 14.4kWh of electricity is required to produce 1kg of liquid aluminum.

- The carbon footprints of electricity generation used in the aluminum industry are 0.33kg CO_2e/kWh in North America (NAS), 0.015kg CO_2e/kWh in Quebec, and 1.19kg CO_2e/kWh in China.
- The transportation distance between Portland and the Chinese manufacturing plant is 11000km (cargo transportation).
- The transportation distance between Portland and the Quebec manufacturing plant is 1200km (transport by truck).
- Emissions related to truck transportation are 1.3E-01 kg CO_2/tkm and 9.3E-05 kg CH_4/tkm.
- Emissions related to cargo transport are 6.3E-3 kg CO_2/tkm and 3.22E-6 kg CH_4/tkm.
- The global warming power (GWP) of methane is 29.7 kgCO_2e/kgCH_4.
- An empty can is made of 0.013kg of aluminum.
- The carbon footprint associated with the production of aluminum ingot in North America is 12.07kg CO_2e/kg aluminum ingot RNA.

Question 1 : By-hand inventory calculation of the alternative scenario

1.1. Calculate the amount of electricity needed to produce 1 kg of aluminium ingot

1.2. On the basis of the carbon footprint of the production of aluminium ingots in northern America (RNA), calculate the carbon footprint of the production of 1kg aluminium ingots in China and in Quebec (help: consider changing the energy mix under consideration)

1.3. Calculate the carbon footprint of aluminium transportation between the aluminium can production factory and the cans filling factory (tkm: transportation of 1 ton on 1 km) for Chinese and Quebec scenario (scaled to the FU).

1.4. Calculate the total carbon footprint of the carbonated water can product system for both scenarios, and compare the results with the original scenario.

Question 2 : Modelling the alternative scenarios with OpenLCA by adapting the original product system

2.1 Modify the aluminum production process to fit the Chinese and Quebec scenarios. To do so, modify the power generation context, and add the transportation process.

2.2 Generate the product systems corresponding to the alternative scenarios and calculate their carbon footprints.

2.3 Compare the results to the results of the original scenario.