Samuel Pélissier - samuel.pelissier@centralesupelec.fr

Lab 2.2. - Running an LCA with OpenLCA

Duration	**Groups**	**Evaluation**
3 hours	2-3	Lab report

1. Today's goal

We want to compare two ways of equipping a computer lab in an engineering school, using OpenLCA along with the BAFU 2026 database. We will follow the goal and scope of a previous study by Loubet et al. (2023)[1]:

- *Functional unit*: "use 600 computers for 5 years in an engineering school".
- *Scenario 1*: 600 desktop computers.
- *Scenario 2*: 600 single-board computers (Raspberry Pi 4) + 6 servers.

The desktop computer and the server are already modelled for you. Your job is the Raspberry Pi, then the comparison. Work in pairs or trios, one OpenLCA per pair.

2. Evaluation

This lab counts towards your final grade. You are expected to send a report within the next 2 weeks (see Edunao for the exact dates).

Lab report:
- Format: **pdf**
- **All student names visible**
- Only answer questions numbered in bold (e.g., **Q1.**). Instructions steps are numbered as S#1.
- When answering questions, the important part is the *thinking*.
  - Short answers based on long thoughts == good.
  - Long answers based on short thoughts == I could've asked an LLM.

[1] Loubet, P., Vincent, A., Collin, A., Dejous, C., Ghiotto, A., Jego, C. (2023). "Life cycle assessment of ICT in higher education: a comparison between desktop and single-board computers." International Journal of Life Cycle Assessment. doi:10.1007/s11367-022-02131-z. Open access: hal-03938948.

3. Setup & anatomy of a unit process

3.1. Setup

S#1. Open OpenLCA. Right click on the left panel called `Navigation` and import the database (New database → From file → BAFU-2026-lab2_students.zolca). This process might take a few seconds. Double click on the database name to open it.

S#2. Open `Processes` → `0_lab`. This folder has been prepared for you and contains a few processes: `Desktop computer (Dell 3620), 5-year life cycle`, `Server (Dell 7920), 5-year life cycle` and `Raspberry Pi 4 board, at plant`.

Everything else lives in the ~12 000 processes of the BAFU database.

> **Advice:**
> 0. You can find processes with the filter box (in the top right corner); avoid browsing the tree directly.
> 1. After typing in a filter box to find a process, click the small **+** next to it to expand all matches, otherwise OpenLCA only shows you the folders.
> 2. Processes depend on geography. **Always check the geography suffix**: `Tap water, at user | CH` (Switzerland) and `Tap water, at user | RER` (Europe).
> 3. The official documentation is available online: https://greendelta.github.io/OpenLCA2-manual/toc.html

Before modelling anything, you need to be able to read what is already in the database. We use the desktop computer for this, because it is the device you will compare against later.

3.2. Walk down the supply chain

S#3. Open `Desktop computer (Dell 3620), 5-year life cycle`. Read the `General information` tab: what is the reference flow, what is the geography, what year is this data from?

S#4. Go to the `Input/Output` tab. OpenLCA uses three icon types: blue cogs (intermediate flows, i.e. the technosphere), green leaves (elementary flows, i.e. the ecosphere), small bins (waste flows). Only two of the three appear here. Which one is missing, and what does that tell you about what this process does and does not describe?

S#5. Each process can be accessed directly to retrieve additional information. Right-click the line `Printed wiring board, mounted, Desktop PC mainboard, at plant` → Open provider. You land on a dataset holding a single line, `Printed wiring board, mounted, Desktop PC mainboard, Pb free, at plant`. Open that provider too; now you have a real inventory. Do it again on `Integrated circuit, IC, logic type, at plant`, and once more from there, landing on `Wafer, fabricated, for integrated circuit, logic type, at plant`. Finally, here, we can find the green leaves we were missing in step 4.

Q1.
You have just walked five levels down a chain that the database stores as a single matrix. At the level you stopped at, are there still intermediate flows left to follow? What does that tell you about where an LCA calculation actually stops?

Q2.
The use phase of this process is one line: 505.43 kWh of French electricity over five years. Suppose your school metered its own machines and you replaced that figure with a measured one. Which parts of the system would then be **foreground** (your own primary data), and which would stay **background** (taken

from the database as-is)? Nothing else you opened in step 5 was measured by whoever modelled the Dell 3620; why does that distinction matter when you report the result?

3.3. Calculate and interpret

> Always use the impact assessment method `EF 3.1 Method (adapted)`. BAFU's elementary flow names are aligned with that method; several of the other methods in the list will silently return zeros for flows they cannot match. You will spend twenty minutes debugging a result that was never computed.

S#6. Back on the desktop computer process, `General information` → `Direct calculation` → `Run calculation`. Accept the memory warning if it appears. Select `EF 3.1 Method (adapted)`, no normalisation/weighting set, calculation type `Lazy / on demand`. Finish.

S#7. Open the `Contribution tree` tab and select the impact category `Climate change`. Expand the top contributors.

Q3.
Give the total climate-change score for one desktop computer, and the three largest contributing processes with their share. Follow the largest one down: which sub-component carries the impact, and inside that sub-component, which one? Write down the chain you found.

S#8. Switch the impact category to `Resource use minerals and metals`, then to `Ionising radiation (human health)`, without changing anything else.

Q4.
Does the ranking of contributors change between the three categories? Take the two largest climate-change contributors and follow each of them into the other two categories. Give the four shares, and a hypothesis for each move.

S#9. Open the `Impact analysis` tab and select `Climate change`. Click on individual processes to see the elementary flows behind them. Then switch this tab to `Resource use minerals and metals` and to `Ionising radiation (human health)`, as you did in step 8.

Q5.
`Contribution tree` and `Impact analysis` both list processes, but they answer different questions. State both questions in one sentence each. Find one process that appears high in `Impact analysis` and nowhere near the top of the `Contribution tree`, and explain the discrepancy.

In `Impact analysis`, find a process that is negligible for climate change and dominant for one of the other two categories, and give a hypothesis as to why. Then look for that same process in the `Contribution tree`, in both categories. The tree does not tell the same story; explain what each of the two views is attributing to it.

> **Checkpoint:** Before moving on, you should be able to tell: where the impacts of a desktop computer come from, and roughly in what proportion.

4. Model a Raspberry Pi 4

Now let's build a device ourselves. The Raspberry Pi 4 model is simple enough that its whole life cycle fits on one page.

4.1. What you are given, and what you build

The eleven electronic components of the board (capacitors, ICs, the PCB, the mounting…) have already been entered for you as a single process, `Raspberry Pi 4 board, at plant`, in `0_lab`. Open it and read its `Input/Output` tab before going further.

Q6.
Two of the eleven lines are expressed by area (in mm²) rather than by mass. Which ones, and why would the authors of those two datasets have chosen area as their declared unit? Now suppose you had to model a board of twice the area carrying the same components: which of the eleven lines would you have to change, and which would stay as they are?

4.2. Create the process

Your job is the **life cycle around that board**: the enclosure, the assembly, the packaging, the transport, five years of use, and the end-of-life.

S#10. Right-click your `0_lab` folder → `New process`. Name it **`Raspberry Pi 4, 5-year life cycle`**.

S#11. The wizard asks for a `quantitative reference`. Choose `Create a new flow`, give it the same name as the process, and set its `reference flow property` to `Number`.

S#12. Set the geography to `FR` in `General information`, and save.

Flow property is not the same thing as unit: You never pick `Item(s)` in the wizard. It is not offered there. You pick a `flow property`, which is the physical dimension the flow is measured in, and OpenLCA then gives you the reference unit of that dimension. `Number` → `Item(s)`. The `Unit` column of the Input/Output table is where you will see it afterwards, and where you can switch to another unit of the same dimension.

Unit needed	kg	m²	kWh	m³	t*km
Flow property	`Mass`	`Area`	`Energy`	`Volume`	`Mass transport`

4.3. Enter the inventory

Add the following data to the newly created Raspberry Pi process (green cross on the right).[2] Don't forget to set the `provider` column on every line with the default value provided by OpenLCA. Some values are missing and will be completed while answering the next questions.

Units, units, units: Be careful when setting units, g vs kg, m vs km, etc.

Additionally, you can type arithmetic directly into an amount cell (e.g. **`0.068/1000*2000`**) and check the result with the `1 2 3` "show values" button.

[2] Foreground inventory of Loubet et al. (2023), Table 5, translated into BAFU process names.

Inputs

Element	Amount	BAFU process	Unit
Board (given)	1	`Raspberry Pi 4 board, at plant`	Item(s)
ABS enclosure	0.05 kg	`Acrylonitrile-butadiene-styrene copolymer, ABS, at plant`	kg
3D-printing electricity	0.375 kWh	`Electricity, low voltage, at grid | CN`	kWh
network cable, cat. 5	3 m	`Cable, network cable, category 5, without plugs, at plant`	m
network plug	1	`Plugs, inlet and outlet, for network cable, at plant`	Item(s)
15 W external PSU	see Q7	`Power supply unit, at plant`	Item(s)
assembly electricity	0.0165 kWh	`Electricity, medium voltage, at grid | CN`	kWh
tap water	9.6 L	`Tap water, at user | RER`	l
packaging	0.02 kg	`Corrugated board, recycling fibre, double wall, at plant | RER`	kg
lorry, 1000 km CN + 1000 km FR	0.136	`Transport, freight, lorry, 16t-32t gross weight, fleet average | RER`	t*km
ship, 15,000 km	1.02	`Transport, transoceanic freight ship`	t*km
use, 5 years	48.62 kWh	`Electricity, low voltage, at grid | FR`	kWh

Outputs (besides your reference flow)

> **On waste:** Those three lines are waste flows:
> - They go in the `Outputs` table, with a positive amount, and should correspond to a flow carrying the small bin icon (not the blue cog).
> - Don't forget to set their provider to the treatment process, as you did for the inputs.

Element	Amount	BAFU process	Unit
waste water	9.6 L	`Treatment, sewage, unpolluted, to wastewater treatment, class 3`	l
end-of-life, device	see Q8	`Disposal, desktop computer, to WEEE treatment`	Item(s)
end-of-life, packaging	0.02 kg	`Disposal, packaging cardboard, 19.6% water, to municipal incineration`	kg

Two lines above say "see Q7/Q8", because BAFU has no dataset for exactly what we need. Let's work this out, shall we?

Q7.
The Raspberry Pi ships with a 15 W external power adapter weighing about 70 g. The only power supply in BAFU is `Power supply unit, at plant`, which is a full desktop ATX unit of roughly 1.4 kg (open it and add up the masses to check; careful, `Sheet rolling, steel` (0.56 kg) is a manufacturing service applied to the `Steel, low-alloyed` (0.56 kg)). Choose an amount, in `Item(s)`, and write down the scaling rule you used and one sentence on why it is defensible. Is your choice likely to over- or under-estimate the impact?

Q8.
The Raspberry board weighs 48 g. The BAFU end-of-life dataset `Disposal, desktop computer, to WEEE treatment` is expressed **per desktop computer**, i.e., per device of about 8.8 kg. Open the corresponding provider (right-click + `Open provider`) and check the two output lines, 6.776 kg to mechanical

dismantling and 2.024 kg to manual. Derive the amount you should enter. Then: this dataset describes shredding and depollution of a device made mostly of steel and plastic. What does using it for a bare PCB do to your result, and in which direction?

4.4. Calculate

S#13. Open `Raspberry Pi 4 board, at plant`, then right-click any component line → `Open provider`, and look at that dataset's own `Input/Output` tab. Do the same on `Desktop computer (Dell 3620), 5-year life cycle`.

S#14. On `Raspberry Pi 4 board, at plant`, `Direct calculation` with `EF 3.1 Method (adapted)`, lazy mode.

Q9.
`Integrated circuit, IC, logic type, at plant` carries 20.5 t*km of transoceanic shipping per kilogram, and the desktop computer carries 180 t*km for a single 8.8 kg machine. Turn both into kilometres per kilogram: what single journey do they describe, and does it match the 15,000 km you entered for the Pi?

So: is the ocean freight you entered for the Pi *additional* to what is already inside the board, or is it the same crossing counted again? Then look up that one line in your `Contribution tree` for `Climate change`, and say whether the size of the error changes anything you would report. Finally: what does that tell you about reading background datasets?

Q10.
Report the climate-change score of one Raspberry Pi 4 over 5 years, split between the production side and the use phase. Which single flow dominates production?

Q11.
The use phase is 48.62 kWh of French electricity over 5 years. Recompute the yearly climate-change impact if the device is kept 10 years instead of 5 (the use phase scales, the production does not). By what percentage do the yearly emissions drop?

4.5. One level down: the Dell motherboard

Now that the circuit board is ready as a single-line process, let's take a look at the desktop computer.

S#15. Create a new process `Dell 3620 motherboard, at plant` the same way as before; new flow, flow property `Number`, with geography `CN`. Enter the data below.[3]

[3] Physical disassembly of a Dell 3620 and a component count run on a photograph of the board (Loubet et al. 2023, Table 3).

Element	Amount	BAFU process	Unit
processor, packaged	6.78 g	`Integrated circuit, IC, logic type, at plant`	kg
processor die, 8 × 8 mm	64 mm²	`Wafer, fabricated, for integrated circuit, logic type, at plant`	m²
42 electrolytic capacitors	54.18 g	`Capacitor, electrolyte type, < 2cm height, at plant`	kg
1064 SMD parts	91.504 g	`Capacitor, SMD type, surface-mounting, at plant`	kg
9 inductors	17 g	`Inductor, low value multilayer chip type, LMCI, at plant`	kg
137 integrated circuits	50 g	`Integrated circuit, IC, logic type, at plant`	kg
PCB, 259 × 259 mm	67081 mm²	`Printed wiring board, surface mount, lead-free surface, at plant`	m²
SMT mounting	67 081 mm²	`Mounting, surface mount technology, Pb-free solder`	m²
3 PCIe + 7 RAM slots	81.2 g	`Connector, PCI bus, at plant`	kg
26 other connectors	182 g	`Connector, computer, peripherical type, at plant`	kg

> Add up only the seven lines you entered in kg: they should come to about *483 g*. The real board weighs 700 g, so the bare PCB accounts for the missing ∼217 g. This is the right order of magnitude for 0.067 m² of populated board. If your seven masses do not sum to roughly 483 g, you have a unit error somewhere.

S#16. *Work on a copy*, so that scenario 1 stays comparable with the other pairs': right-click `Desktop computer (Dell 3620), 5-year life cycle` → `Duplicate`, and rename the copy **`Desktop computer, my motherboard`**. In the copy, find the line `Printed wiring board, mounted, Desktop PC mainboard, at plant` (0.757 kg) and replace it by *your* motherboard process, 1 Item(s). Save, and calculate *both* the original and the copy.

Q12.

BAFU's generic mainboard is 0.757 kg modelled as one aggregate dataset; yours is 0.700 kg built from a count of 1200+ individual components. By how much does the desktop computer's climate-change score move when you swap one for the other? Given the effort that second model took, what does the size of that change tell you about when sub-component detail is worth collecting? In which impact categories would you expect it to matter more than in climate change?

5. Comparison

At this point, all of our options are ready for comparison.

5.1. Build the product systems

S#17. On each of your three processes (your Raspberry Pi, `Desktop computer (Dell 3620), 5-year life cycle` and `Server (Dell 7920), 5-year life cycle`): `General information` → `Create product system` (left of `Direct calculation`) → accept the defaults. Each should now appear under `Product systems` on the left pane.

S#18. Open one of the resulting product systems and look at the `Model graph` tab to see the supply chain OpenLCA has just built explicitly.

S#19. Right-click `Projects` → `New project`, name it **`Lab computers`**. Drag your product systems into `Compared product systems`. Rename the variants to something readable.

S#20. Set the amounts to the functional unit: *600* desktop computers for scenario 1; *600* Raspberry Pi and *6* servers for scenario 2. Select `EF 3.1 Method (adapted)`, tick `Create report`, save, then `Calculate`.

> **A project compares variants, not scenarios:** You will get three bars, one per product system: 600 desktops, 600 Raspberry Pis, 6 servers. Scenario 2 is the second plus the third.

Q13.
Does either scenario win in all EF 3.1 categories? Give the reduction on climate change, **along with a screenshot of the relevant graph**. What do the narrowest categories have in common, and what does that predict about running the same comparison in a country with a different electricity mix? (You will test that prediction in Q15.)

Q14.
Scenario 2 has 100 times more Raspberry Pis than servers. Look at the split between the two device types. Is the ratio of impacts 100:1? What does that tell you about centralising computation?

5.2. Sensitivity

Change one assumption at a time and recalculate. You do not need to redo the whole project for each: copy the process, change the line, and compare.

Q15.
Replace the use-phase `Electricity, low voltage, at grid | FR` by `| PL` in both scenarios. What happens to the relative weight of production versus use? Does the ranking of the two scenarios survive? What does that say about exporting this conclusion to another country?

Q16.
Suppose the Raspberry Pi only lasts 2.5 years, so scenario 2 needs 1200 of them over the functional unit. Careful: the functional unit is still five years of use, so doubling the whole life-cycle process would count the use phase twice; only the production side doubles. Recompute. Is scenario 2 still preferable? By how much is the margin reduced?

Q17.
You have just done two sensitivity analyses (electricity source/mix and usage lifetime). Classify each one: is it a `parameter` choice, a `scenario` choice, or a `model` choice? Do they influence the report made to a decision-maker, and why?

6. Wrap-up

Q18.
"142 tonnes of CO_2 eq per functional unit" can be hard to visualise. Express your two scenario totals in other forms: per student per year over a three-year degree, and as a fraction of one French person's annual carbon footprint. If needed, you can use the Web to retrieve missing figures. Does the gap between the two scenarios look more or less decisive once expressed this way, and why?

Q19.
You computed a single number for a scenario made of 600 devices, using datasets for electronic components compiled in the mid-2000s, a proxy power supply you chose yourself, and an end-of-life dataset for a different device. In one paragraph, state what your result supports and what it does not; would you call scenario 2 "sustainable"?

Source study: Loubet, Vincent, Collin, Dejous, Ghiotto & Jego. "Life cycle assessment of ICT in higher education: a comparison between desktop and single-board computers." Int. J. Life Cycle Assessment (2023). https://doi.org/10.1007/s11367-022-02131-z
Database: BAFU 2026 v1.1 (Swiss Federal Office for the Environment), free on https://nexus.OpenLCA.org. Software: OpenLCA 2.7.