INNOMAT

LEARNING & TRAINING PACKAGES

COURSEBOOK

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Content

Introduction

Are you a business manager, designer, or student, and do you want to introduce a green product in mainstream markets?
Then you might have additional, detailed questions like:

a. How 'green' is my product, and is my product or service better for the environment than existing products?
b. Do I run the risk of materials scarcity (i.e. shortages in the supply chain)?
c. What is my (circular) business model that I will need for successful market introduction?
d. How do I create the maximum 'eco-efficiency' of my product innovation?

In this coursebook you will find short explanations, examples, and exercises that accompany the videos of the Innomat learning and training package.
The training package comprises 4 Modules on the abovementioned 4 issues:

I. 3 training videos on Life Cycle Assessment (LCA:
   Block 1. Introduction (what is it, and what it is used for)
   Block 2. The Basics that you need to know to be able to make an LCA yourself
   Block 3. How to make an LCA of circular systems
II. A training video on the issue of materials scarcity (what is it and how to deal with it in LCA?)
III. A training video on the development of circular business models
IV. A training video on the method of Eco-efficient Value Creation (innovation of products and services)

This coursebook comprises 9 assignments that follow from the videos:

1. Discover the differences between the carbon footprint of materials like metals, plastics, bioplastics, and wood by using the IDEMAT app (in IOS or Android)
2. Make your own LCA calculation on the redesign of a felt-tip pen
3. Compare a few alternatives at the end-of-life of products (the eco-costs of land-fill, combustion with heat recovery, closed loop recycling, of different kind of materials like metals, wood, plastics, biobased plastics)
4. Compare a rechargeable battery vs a single use alkaline
5. Check resource scarcity scores in eco-costs, ReciPe, and the EF (CML), for Cobalt and Nickel. Which of these scores are aligned with the trend to minimize Cobalt in car batteries? And which are not aligned?
6. Design your own sustainable business model for an innovative company in the BEV (battery electric car) industry
7. Load the IdemantLightLCA app (in IOS or Android), Look at the instruction video 2 at www.idematapp.com, and make the felt-tip LCA (Module 1) at this app
8. Make your own calculation on the eco-costs/value ratio of four types of chairs: which is the most sustainable chair type?
9. Compare four Nespresso coffee cup concepts: What sustainable alternative do you have for the Aluminium coffee cups?

Module 1 Block 1: LCA, Introduction

Assignment 1

Discover the differences between the carbon footprint of materials like metals, plastics, bioplastics, and wood by using the IDEMAT app (in IOS or Android)

The issue.

You saw in the video the LCA is to benchmark products (is product A better than product B?).
The issue here is that, in our modern society with internet, there is a lot of fake news, especially in the field of environmental issues. Guts feel and self-interest often determine what is presented as good and what is bad, rather than sound analyses. So there is a lot of misinformation in social internet bubbles.
For products that don't consume energy in the use phase, the materials in the product often determine more than 80% of the environmental burden in the production chain, so it is important to have some objective knowledge about it.
Since it is a heck of a job to gather information on energy and mass-flows, and calculate the environmental burden, LCA open access data are used of peer reviewed scientific papers, and trusted organisations like universities.

The tool.

You must download an app with the name **Idemat** (for Android you need version 8 or higher; for IOS you need version 9 or higher), and you must look at instruction video 1 at www.idematapp.com .
(when you arrived at the detailed product page, tick the green block for getting the CO2e data)

The assignment

Fill in the following table:

name of material	kg CO2e/kg with **landfill** (without waste treatment)	kg CO2e/kg with **waste treatment** in Western Europe	Kg CO2e/kg with closed loop recycling (**circular business solutions**)
Carbon steel, market mix	0.96 (=0.96 +0.00)	0.96 (=0.96 +0.00)	0.65 (= 0.96 -0.31)
Copper, wire, plate, trade mix			
Aluminium, market mix			
PVC, market mix			
PLA (biodegradable)			
PET, bottle grade			
Mechanical recycled plastics *)			
Meranti, FSC, class II			
Meranti, natural forests, cl II			

*) rPET, rPE, rPP, rPVC, (downcycled thermoplasts)

Short explanation of the columns:
- the 'landfill' column shows the carbon footprint in the case that the product is dumped after its end-of-life
- the 'waste treatment' column gives the case that the waste is separated, and recycled (metals, glass, some plastics), or burned with heat recovery (wood, paper, plastics)
- in the 'closed loop' column, the material is upcycled to be used in the same type of product (so that the material does not leave the circular product chain of the same type of product, managed under the responsibility of the manufacturing company)

Some observations and explanations of data in the tables:

a. The carbon footprint of upcycled metals is **always lower** than the market mix. The benefit of closed loop recycling goes to the product under study. The benefit of 'open loop recycling' in the case of waste treatment in Western Europe goes to the next, yet unknown, product chain (see 'secondary' metals in the list), so double counting of the benefit is avoided. See for further explanation the video of Block 3.
b. The carbon footprint of upcycled plastics is **often more** than of virgin or market mix plastics (it requires a lot of energy "to cut the molecule-chains back in pieces"). The Ioniqa process for upcycling of PET is a positive exception: 1.26 kg CO2/kg, 0.93kg CO2/kg less than landfill.
c. Mechanical recycling of plastics (rPET, rPE, rPP, rPVC) has the lowest carbon footprint of plastics, however, this is a form of downcycling (it requires clean plastics, and the quality degrades in each recycling step)
d. The carbon footprint of FSC wood is governed by its transport (note that the transport is to a warehouse in Rotterdam). The carbon footprint of Maranti 'natural forest' includes the loss of carbon storage in the rain forests. (Note that **FSC** wood keeps the forests in a 'steady state', so there is over a large area **no decrease of carbon storage**)
e. The negative carbon footprint of wood at the end-of-life is caused by burning with heat recovery, which is explained in the video of Block 3 (a credit for avoided fossil fuels)
f. The main reason to recycle metals like copper is not the moderate reduction of CO2 emissions, but the issue of metals scarcity. Note that the subject metals scarcity (depletion) is not part of the carbon footprint calculation, and is therefore not counted. This is one of the major shortcomings of the carbon footprint in the analyses of C2C systems.
g. The best end-of-life scenario for most of fossil based plastics, like PVC, is landfill in carbon footprint calculations(!) The reason is that waste incineration generates a lot of CO2, and upcycling requires a lot of energy. On the other hand, landfill requires no extra energy at all. This is obviously also a major shortcoming of carbon footprint calculations: the materials scarcity and the 'plastic soup' are not part of the calculation system.

Conclusion: Despite of the fact that the carbon footprint is an excellent indicator for energy production systems and for calculations on energy consumption, it is not a good indicator for materials selection, since it does not deal with important environmental aspects like materials scarcity, the plastic soup, biodiversity, water, as well as human toxicity and eco-toxicity.
This issue is dealt with in the next video (Block 2).

<u>Extra assignment</u>
The following table gives the percentage of ' circular' / 'landfill' (column 4 / column 2 of the previous table) for the CO2e system, as well as this percentage in the eco-costs system.
Check these data (use the IDEMAT app to find the data for eco-costs). Correct the data with the newest available data in Idemat.

name of material	circular / landfill **in CO2e**	circular / landfill **in eco-costs**
Copper, wire, plate, trade mix	25%	3.75 %
PET, bottle grade	58 %	31 %
PVC, market mix	117%	50%

Note. The fastest way to create the first table is using the IdematLightLca app. This app is used in Assignment 7 of this book, and it is a bit more complex than the Idemat app: it has an LCA calculation model in it. To create the table you must start an LCA calculation (provide name and description), add the data lines of the table, assign each line 1 kg, and press calculate. Touch the green block, and you see the data for the 3 scenarios.

Module 1 Block 2: LCA, the Basics

Assignment 2: LCA of the felt-tip pen
Make your own LCA calculation on the redesign of a felt-tip pen

The issue.
In the video you saw an example of a simple LCA. This assignment is to make sure that you can make such a calculation yourself.

The tool.
The excel table IDEMAT from the website www.ecocostsvalue.com:
page https://www.ecocostsvalue.com/data-tools-books/

The assignment.

You are asked to perform a "simplified" Life Cycle Analysis (LCA) of a felt-tip pen by assessing 3 scenarios: one called "classical" (the bases case), one called "technological" (case 1) and another one called "circular" (case 2). The base case is close to the reality. In case 1, a change of materials is proposed to measure possible environmental gains. In case 3, the "circular" scenario, the Aluminium is recycled and used in the next product.
N.B. You should use your time efficiently!

Functional Unit
Felt-pen life span: 6 months. Use: 2 hours a day
The felt-pen is at its end-of-life when it doesn't work anymore.
The declared unit (also called functional unit) of your calculation is 1000 felt-tip pens.

Product details for manufacturing

Cap	**Support for felt**	**Felt**	**Ink cartridge**	**Body**	**Ink**
2g	2g	1g	4g	4g	15g
Polythene	Polythene	Polyamide	Polyester	Aluminium	ethanol
Injection moulding	Injection moulding			Extrusion	
					

Assembly
The product assembly requires 1MJ/kg.
Logistics
The transport of the pen as well as of the materials in it is:
330 km by truck and trailer (24 ton)
450 km by train

Use
During the use phase, the product rejects ethanol in the atmosphere. These are the **foreground emissions** in this system. The eco-costs of such foreground emissions can be found in table "ecocosts20.. V.-. midpoint tables" at page https://www.ecocostsvalue.com/data-tools-books/
(Note: the **production** of ethanol for the felt-tip is in the background table Idematapp)

End of Life
At the end of life, the product is discarded together with household waste (i.e. waste treatment of Western European municipalities).

Alternative scenarios
Since the Aluminium body of the pen is the hot spot, we will look at alternatives for the body
Case 2
Similar to the base case but the aluminium body is replaced by a polythene one. Its weight is then 15g. When you look in the tables, you will immediately see that normal PE is not a good solution: you should apply bio-PE, since that gives an enormous credit when it is incinerated with heat recovery at the end-of-life (in a municipal waste incineration with electricity)
The question is: how much reduction of eco-costs is achieved by this technical design change (compared to the base case design). Note that you need extrusion of PE in manufacturing.
Case 3
The design is now similar to the base case, but the end-of-life differs. There is a take-back system of the pens and the aluminium is recycled. Assume in your calculation 100% recycling.
The question is: how much reduction of eco-costs is achieved by this circularity (closed loop recycling), compared to the base case.

Note that you may only look at the differences of the calculation of the base case: so you compare the body only (and you may neglect the increase of weight of the transport).

When you think that a more realistic scenario is 50% recycling, then the result will be the average of the base case and case 3.

Note.
On your output: There are slight differences with the calculation in de video, Model 1, Block 2. This is caused by the fact that the videos have Idemat 2020 data, and your calculation is based on the most recent Idemat data (each academic year the LCA data are updated). For exact comparison you may take either the Idematapp, the IdematLightLca app or data from the website page
https://www.ecocostsvalue.com/data-tools-books/

Module 1 Block 3: LCA, cradle-to-cradle

<u>Assignment 3: comparison of end-of-life/cradle-to-cradle scenarios</u>
Compare a few alternatives at the end-of-life of products

<u>The issue.</u>
In the previous assignment, you saw already the reduction of eco-costs by closed loop recycling. This assignment is to give you some feel for the different eco-costs for different end-of-life scenarios.

<u>The tool.</u>
The Idemat app or the IdematLightLCA app.

<u>The assignment</u>
Fill in the following table:

name of material	eco-costs (€/kg) with **landfill** (without waste treatment)	eco-costs (€/kg) with **waste treatment** in Western Europe	eco-costs (€/kg) with closed loop recycling (**circular business solutions**)
Carbon steel, trade mix			
Copper, wire, plate, trade mix			
Aluminium, trade mix			
PVC, trade mix			
PET, bottle grade			
Mechanical recycled plastics			
Meranti, FSC, class II			
Meranti, natural forests, cl II			

This table looks rather different from the table of the first assignment. The reason is quite simple, since the table of the first assignment looked only at the carbon footprint. In the eco-costs extra issues are added to the issue of carbon footprint. The main differences are caused by:

- Metals: the issue of metals scarcity
- Plastics: the issue of scarcity of energy carriers and the issue of the plastic soup
- Wood: the issue of biodiversity
- Textiles: the issue of water scarcity

The marginal prevention costs which are the basis for eco-costs can be found at www.ecocostsvalue.com tab eco-costs. Each group of materials appear to have its own governing midpoint group.

Assignment 4: batteries (rechargeable or not)

Compare a rechargeable battery vs a single use alkaline battery that is used for the electrical power of a bicycle lamp

The issue.

In the previous assignment, you looked at materials in products. Now we will look at the system level: re-usable versus throwaway products.

The tool.

The excel table Idemat from the website page https://www.ecocostsvalue.com/data-tools-books/

The assignment

The question

The basic question of this assignment is: is system A better than system B?
The answer will depend on the number of years that the rechargeable system is used

Functional unit

Supply power to the bicycle lighting system (power : 960mWh) during one year (equivalent to 90h of lighting).

Declared units

System A. Single use alkaline battery (Zn-MnO2)
- 2 batteries are necessary for the lighting system per year
- The two batteries can supply the power during 3.3h
- For the functional unit of 1 year, 2 x 26 batteries are necessary

System B. Rechargeable batteries (Ni-Cd)
- 2 batteries are necessary for the lighting system
- For the functional unit of 1 year, 33 cycles of charge are necessary
- plus a charger

The system and its boundaries

Calculate required materials only (so neglect product assembly, packaging, transport, and end-of-life), plus the electricity that is used. Assume that the required electrical power is the same for both systems (so that in the comparison, the electricity is the same, and can be neglected therefor).

Life span of the charger

The technical life span of the charger is more than 1000 cycles, however, assume that the charger will be discarded much earlier.
Make 3 calculations: (a) 1 year life span (b) 1.5 year life span (c) 2 years life span

End of Life

At the end of life, the product is discarded together with household waste (i.e. waste treatment of Western European municipalities).

The Bill Of Materials (BOM)

Use the BOM of the tables at the next pages to make the LCA(s). The materials can be found in the Idemat tables (don’t use the direct data for batteries in Idemat):

BOM (bill of materials of a alkaline battery

Battery parts	Materials	Weight (g)	Process
Anode	Zn	3	No
	ZnO	0.8	No
	KOH	0.66	No
	Brass	0.44	No
	Steel	0.29	No
Cathode	MnO2	7.5	No
	C (graphite	4.1	No
	KOH	0.6	No
	Steel	4	No
Separator	Paper	0.11	
Isolation	Cardboard	0.06	
Metals parts	Steel	0.38	Steel production
Plastic parts	PVC	0.23	Injection
	Polyamide	0.22	Injection

BOM (bill of materials of a Rechargeable battery (Ni-Cd)

Battery parts	Materials	Weight (g)	Process
Anode	Nickel	8.2	No
	KOH	0.6	No
Cathode	Cadmium	15.5	No
	KOH	0.6	No
Separator	Paper	0.11	
Isolation	Cardboard	0.06	
Metals parts	Steel	0.38	Steel production
Plastic parts	PVC	0.23	Injection
	Polyamide	0.22	Injection

BOM (bill of materials) of a Charger

Materials	Weight (g)
Polypropylene	288
Copper	178
PVC	7
Steel	78
Iron (magnetic)	150
Cardboard	10
Electronic card	20

Step 1: make an LCA of the 3 system components. Step 2: compose system A and system B

How to do step 1 (the 3 system components) as fast and as efficient as possible:
1. In LCA benchmarking you can apply “streamlined LCA’, which means that all subsystems which are identical at both sides of the comparison can be neglected. Example: the required energy from the grid is the same, so do not incorporate that in your calculation.
2. first make (rearrange) your bill of materials, having for each material a line for the raw material, the processing, and the EoL
3. Do not make your EoL complex: it is a best guess anyway, that differs for each country (use normally 1 EoL process for 100% of the flow, per material)
Be aware that the benefit of metals recycling goes to the next user (so the benefit for the manufacturer of the batteries have EoL = 0), since this case is open loop recycling
4. After the BoM, copy paste in the same sheet at the right side all relevant lines from the Idemat excel (copy a bit more then you need, so you can make alternative choices later (e.g. virgin, secondary, market mix data), to check the influence of choices at your hot spots
5. Then copy paste the relevant eco-burden data “per kg” behind each BoM line
6. Calculate the columns “per declared unit” in the columns after 5. You will experience that the calculation as such is hardly any work.
7. **Do the LCA for eco-costs as well as carbon footprint**

Step 2: Compose your System A and System B.
The result is that you see the best system (for *one year* use phase).
Which system is the best in eco-costs?
Which system is the best in carbon footprint?

Note (additional information.
The advantage of System B is more when the systems are used for more than one year.
See the table below (you might end up with a different table, because you are using more recent Idemat data).

life time		eco-costs (euro/year)	carbon footprint (kg CO2e/year)
1 year	52 single-use batteries	1.18	3.19
1 year	2 rechargeables + charger	2.10	2.58
1.5 year	2 rechargeables + charger	1.40	1.72
2 year	2 rechargeables + charger	1.05	1.29

When you look at the hotspots in your calculation, you see in eco-costs that Cadmium is a hotspot for the single-use batteries and that Copper is the hotspot for the charger system. So materials scarcity is an important issue in the eco-costs calculation, rather than the carbon footprint.
So how realistic is the comparison without taking materials scarcity in consideration?

You may read for additional information:

Vogtländer, JG. A practical Guide to LCA for students, designers, and business managers: cradle-to-grave and cradle-to-cradle. Fifth edition, 2017. Delft Academic Press (VSSD Publishers), Delft.

Module 2: Critical Raw Materials and LCA

<u>Assignment 5: scarcity scores in eco-costs, ReCiPe and EF</u>

Check resource scarcity scores in eco-costs, ReciPe, and the Environmental Footprint (EF, CML), for Cobalt and Nickel.
Which of these scores are aligned with the trend to minimize Cobalt in car batteries? And which are not aligned?

<u>The issue.</u>
The issue is here whether or not an indicator system guides you in the right direction, again with the question "is A better than B".

<u>The tool.</u>
The excel table Idemat 2024 from the website www.ecocostsvalue.com, tab Data,Tools,Books
https://www.ecocostsvalue.com/EVR/img/Innomat-teaching-materials/Idemat_2024-V2-1c.xlsx

tab 'Idemat2024 midpoints' and columns S, BH and CC

<u>The assignment</u>
<u>The question</u>
It is generally accepted that Cobalt is more scarce than Nickel, but what do our indicator systems indicate? Fill in the table below (data from the Idemat, tab Idemat2022 midpoints, and tab EF system (adapted) for PEF

name indicator system	Cobalt score materials scarcity	Nickel score materials scarcity
ReCiPe, mineral resources scarcity ($)		
Ecological Footprint, resources, mineral (pt)		
Eco-costs of resources (euro)		

You can observe in the table that Nickel scores higher (i.e. worse for sustainability) than Cobalt in Ecological Footprint.
In Eco-costs and ReCiPe it is the other way around.

So eco-costs and ReCiPe are the only indicator that guides in the right direction with regard to the replacement of Cobalt by Nickel in car batteries.
In general ReCiPe is right in most cases, but that the Abiotic Depletion Potential, ADP, of EF (CML) is often totally wrong. The reason is that the ADP is based on wrong assumptions, see the scientific paper below for additional information (Introduction, Appendix C, and Fig 9, Fig10)

You may read for additional information:

Vogtländer, J, Peck D, Kurowicka D. The Eco-Costs of Material Scarcity, a Resource Indicator for LCA, Derived from a Statistical Analysis on Excessive Price Peaks, *Sustainability 2019*

Module 3: Circular Business Model canvas

Assignment 6: design your own canvas

Design your own sustainable business model for an innovative company in the BEV (battery electric car) industry

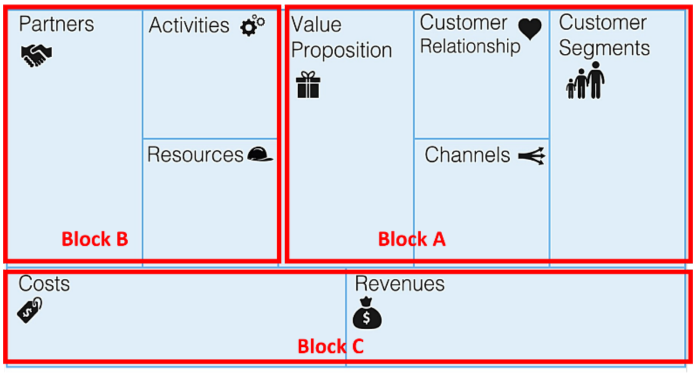
The issue.
Designing a circular business model is not simple, but the business canvas might help with it. The canvas provides a structure that appears very helpful in designing viable business models at a conceptual level. The canvas works the best in brainstorming-type sessions with 3 – 5 people (1 – 3 hours), but when you take your time, it is also possible to use it on your own.

The tool.
The canvas sheets can be downloaded from https://www.ecocostsvalue.com/EVR/img/Innomat-teaching-materials/business_canvas_sheets.pptx
It is advised to print the sheets on large sheets of paper (minimum A3) and use post-it notes.

The assignment

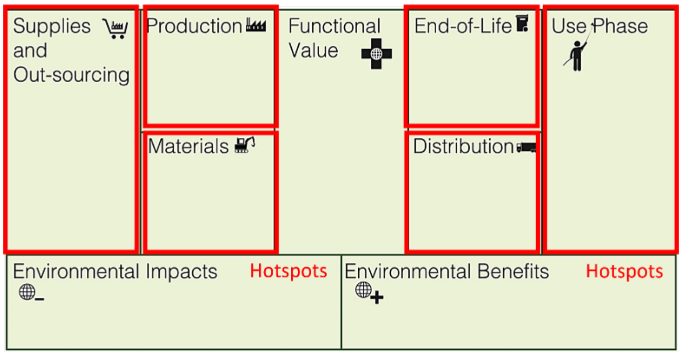
Do it step by step:

1. Fill in block A of the economic canvas
2. Fill in block B of the economic canvas
3. Fill in Block C of the economic canvas

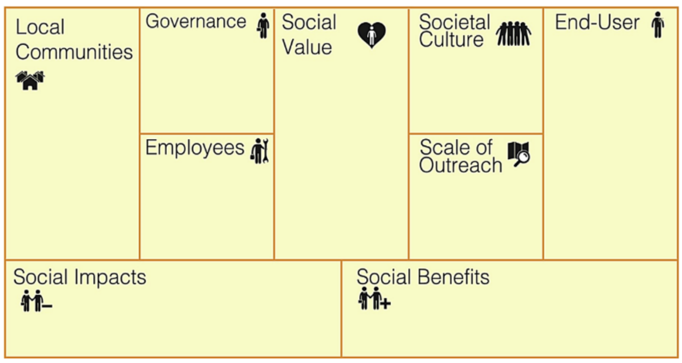


4. Make an Fast Track LCA of your product service combination

5. Fill in the eco-costs of the main activities in the red blocks of the the environmental canvas
6. Fill in how to improve in the red blocks
7. Fill in your main improvement actions in the lower two blocks



8. Fill in the social canvas, as far as it is not the social benefit for yourself and your clients.



The theory is from:
Joyce A., Paquin R.L. 2016. The triple layered business model canvas: A tool to design more sustainable business models. Journal of Cleaner Production 135 474-1486

Module 4 Block 1: Eco-efficient Value Creation (EVC)

<u>Assignment 7: the IdematLightLCA app</u>

Load the IdematLightLCA app (in IOS or Android),
Look at the instruction video 2 at www.idematapp.com
Note: be sure that your iPhone is not set to the dark mode (you don't see then your type in)

Make the felt-tip LCA (Module 1) at this app

<u>The issue</u>

The Fast track LCA method by means of the excel tables is much faster than the classical LCA, but sometimes it is not fast enough.
For that reason the IdematLightLCA has been developed to have LCA available at your smartphone ("at your finger tip"). The app is based on about half of the most used LCIs of the Idematapp excel table, and gives estimates for 3 end-of-life scenarios: land fill, municipal waste treatment, and circular business system (assumption: 100% recycling).

<u>The tool</u>

Download the IdematLightLCA app, available for IOS (version 9 or higher) and Android (version 8 or higher).
Look at the instruction video 2, a least until minute 4 (the rest might be of interest pro people who have data from Environmental Product Declarations, EPDs)

<u>The assignment</u>

<u>*Functional Unit*</u>

Felt-pen life span: 6 months. Use: 2 hours a day
The felt-pen is at its end-of-life when it doesn't work anymore.
The declared unit (also called functional unit) of your calculation is 1000 felt-tip pens.

<u>*Product details for manufacturing*</u>

Cap	**Support for felt**	**Felt**	**Ink cartridge**	**Body**	**Ink**
2g	2g	1g	4g	4g	15g
Polythene (=PE)	Polythene (=PE)	Polyamide (=Nylon)	Polyester	Aluminium	ethanol
Injection moulding	Injection moulding			Extrusion (=Forging)	
					

<u>*Assembly*</u>

The product assembly requires 1MJ/kg.

<u>*Logistics*</u>

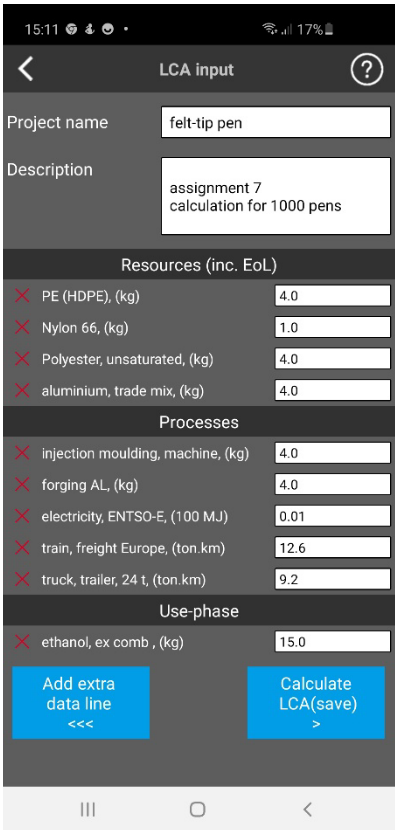
The transport of the pen as well as of the materials in it is:
330 km by truck and trailer (24 ton)
450 km by train

<u>*Use and End-of-Life*</u>

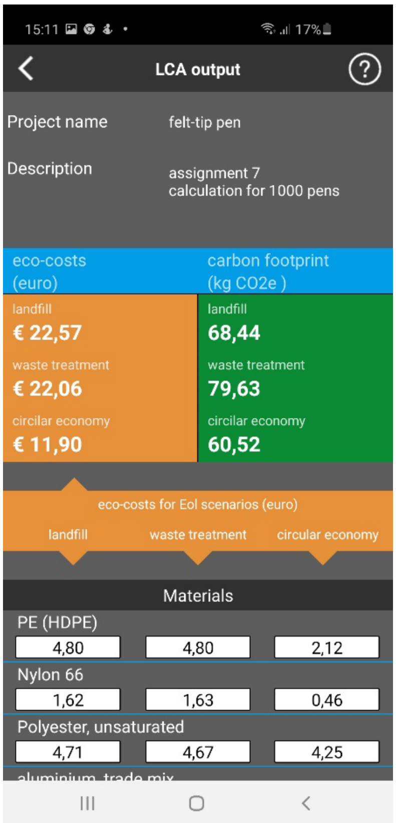
We neglect the ethanol emissions in the use-phase, and we take the 3 standard End-of-life scenarios of the app.

The calculation

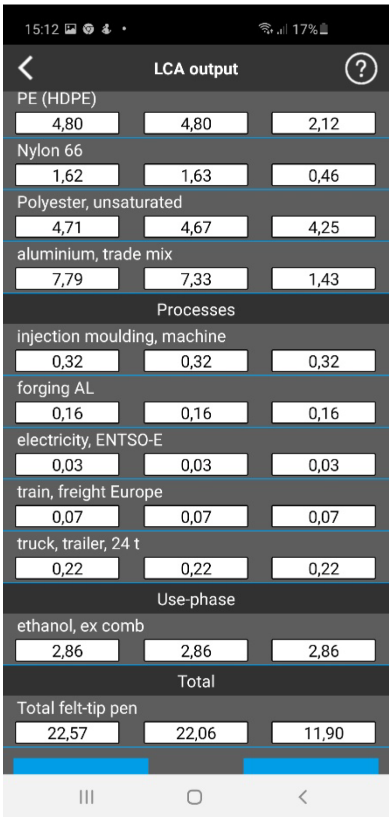
INPUT



OUTPUT (top)



OUTPUT (bottom)



Note 1.
On the input: The background process of ethanol can be found under ‘Other’>’Energy & Fuels’
Note 2.
On the output: The 2nd column shows the base case of Assignment 2, Module1, Block 2. The 3rd column shows the closed loop, circular business case. It can be seen that, apart from closed loop recycling of Aluminium, closed loop recycling of PE and Nylon also reduces the eco-costs.
Note 3.
On your output: There are slight differences with the calculation in de video, Model 1, Block 2. This is caused by the fact that the videos have Idematapp2020 data, and your calculation is based on Idematapp2021 data (each academic year the LCA data are updated). For exact comparison you may take the Idematapp2020 from the website www.ecocostsvalue.com tab data.

Module 4 Block 2: EVC, exercise and assignments

Assignment 8: LCA benchmarking of 4 chairs

Example of EVR benchmarking: different types of chairs

The issue

In the fuzzy front end of the design of innovative products, there is a need to have a quick overview of products in the Eco-costs Value Ratio product portfolio matrix. Since the design of a product depends on its end-of-life (landfill, municipal waste treatment, or a circular business solution), it is good to now these 3 end-of-life alternatives in the portfolio.
The IdematLightLCA app has been developed for this type of benchmarking.

The tool

The IdematLightLCA app

The assignment

Functional Unit

The declared unit is one chair.

Product details

Bamboo chair
€ 10.00
4.6 kg
electrical power 2.2 MJ
Sea container 0.05 m3
20.000 km
municipal waste incineration

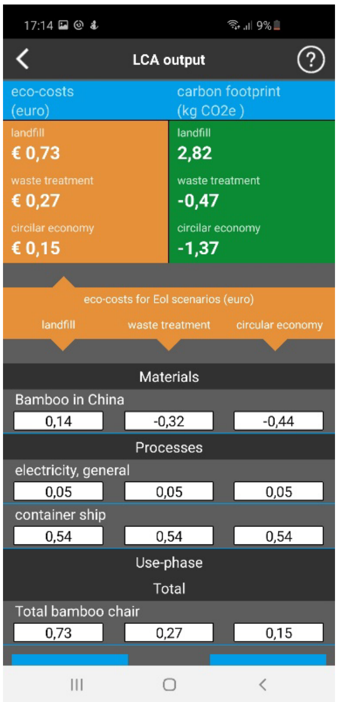
Oak chair
€18.00
4.3 kg
no paint
Truck&trailer 0.05 m3
500 km
municipal waste incineration

Steel chair
€23.00
4.98 kg
Powder coating 1.1 m2
Truck&trailer 0.05 m3
500 km
municipal waste open loop recycling

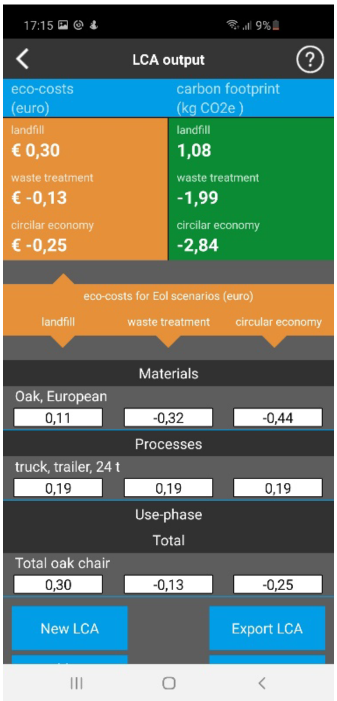
Plastic chair
€11.00
PP - 2.92 kg
Injection moulding
Truck&trailer 0.05 m3
500 km
municipal waste incineration

__The calculation__

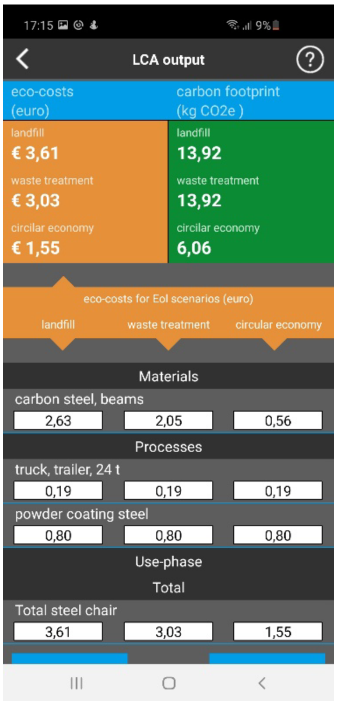
bamboo chair



oak chair

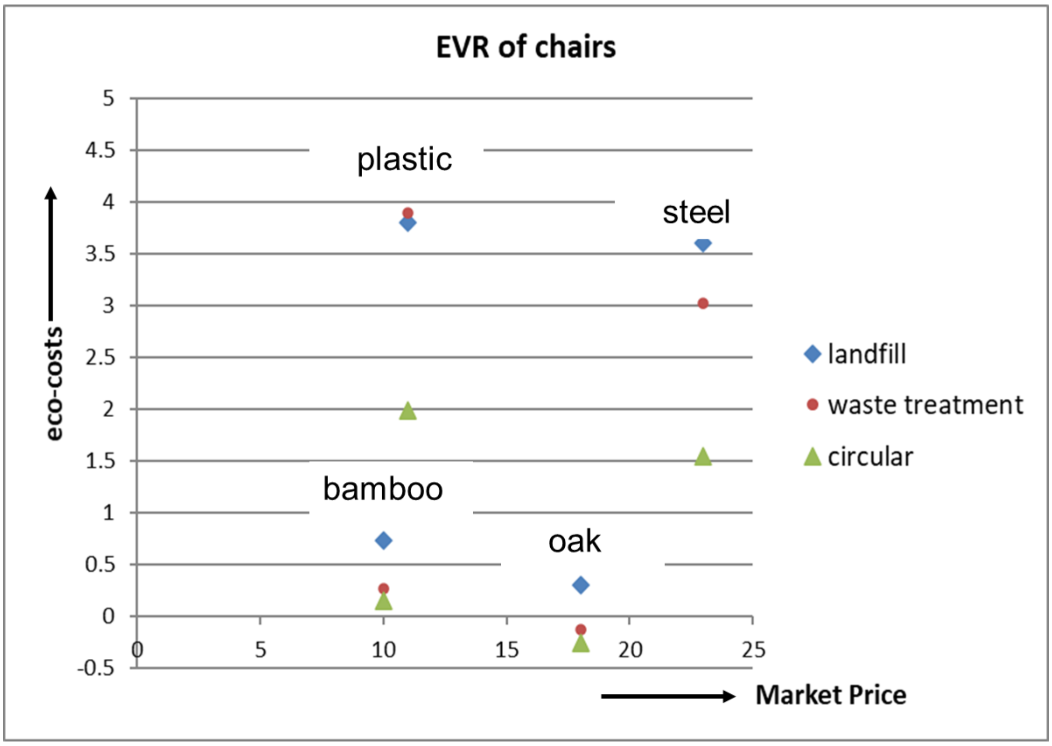


steel chair



plastic chair

__The results__



What you see is that oak scores the best. The eco-burden score is even negative when, after the use phase, it is burned with heat recovery, so it has an end-of-life credit. Note that burning of wood is here at the 'real' end-of-life, when reuse (and recycling) is not feasible anymore.

Assignment 9: the Nespresso case

Compare four Nespresso coffee cup concepts: What solution do you have as an alternative for the Aluminium coffee cups?

The issue

- Environmental pressure groups accuse Nestle of applying Aluminium coffee cups as being disastrous for the environment, e.g. Die Deutsche Umwelthilfe (DUH)
- The issue is that Nestle claims that AL is a good solution, when it is 100% recycled
- The pressure groups say that this is not a good solution, since even in Switzerland the recycling rate is not higher than 50%, already for many years (in the Netherlands approx. 23%, in Germany not know, but not higher than 50%)
- Nestle says that the consumer should change his or her behaviour, but the pressure groups say that Nestle should apply another material
- Nestle has announced that they will use virgin Al from Rio Tinto that uses electricity from hydro-electric power plants as of 2020 (which reduces the eco-costs of CO_2 from 1.17 to 0.46 euro per kg)
- Nestle claims that Al is required to maintain the coffee quality standard, but is that true? EVOH blocks all gasses as well. Or take biodegradable plastic cups in a metal container (instead of cardboard)

Supporting reading materials, see the URLs below (You might use Google to translate in English):
https://www.nestle.de/storys/kaffeekapseln-recycling#
https://recyclingportal.eu/Archive/43161
https://www.faz.net/aktuell/wirtschaft/streit-um-die-kaffeekapsel-14979481.html
https://www.br.de/radio/bayern1/inhalt/experten-tipps/umweltkommissar/kaffee-kapseln-pads-umwelt-100.html
https://www.nu.nl/economie/5581655/nespresso-wil-in-2020-duurzamer-aluminium-gebruiken-koffiecapsules.html
https://www.theatlantic.com/technology/archive/2015/03/the-abominable-k-cup-coffee-pod-environment-problem/386501/

Supporting videos:

- The advertisement of Nespresso: https://www.youtube.com/watch?v=aM20MRUPSTk
- The response to it of an NGO: https://player.vimeo.com/video/116606409

The tool

You need for this assignment the IdematLightLCA app

The assignmnet

Note: the original assignment is for a group of participants, however you canb try it on your own as well. You should follow the step by step instruction below.

Step 1. Make a group inventory on the Willingness to Pay for different kind of coffee cups: (1) Al, (2) PP with EVOH layer, (3) biodegradable plastics in steel storage container (to keep the coffee cups fresh), or other ideas.
Use post-its. Note. EVOH is a polymer that blocks gasses as good as Aluminium.

Step 2. Create groups of 3 – 4 participants

Step 3. Estimate the eco-costs of the Al solutions (“virgin” and “RioTinto virgin” for 50% recycling. Benchmark materials only, including end-of-life, for 1 kg Al (= 1000 cups).
See also the Note on Rio Tinto after step 7

Step 4. Estimate the eco-costs of the EVOH on a bio-PE concept (10% EVOH, 90% bio-PE). Benchmark materials plus end-of-life only. Calculate also bio-PE without EVOH (you will need a tin then to keep the coffee fresh for a longer period, neglect the eco-burden of the tin since the tin is assumed to have a very long lifespan).

Step 5. Plot each solution in the 2 dimensional EVR matrix, assume that the Al coffee cup price is 0.35 euro and the plastic cup price is 0.30 euro

Step 6. Decide on your best options

Step 7. Report your findings to the group

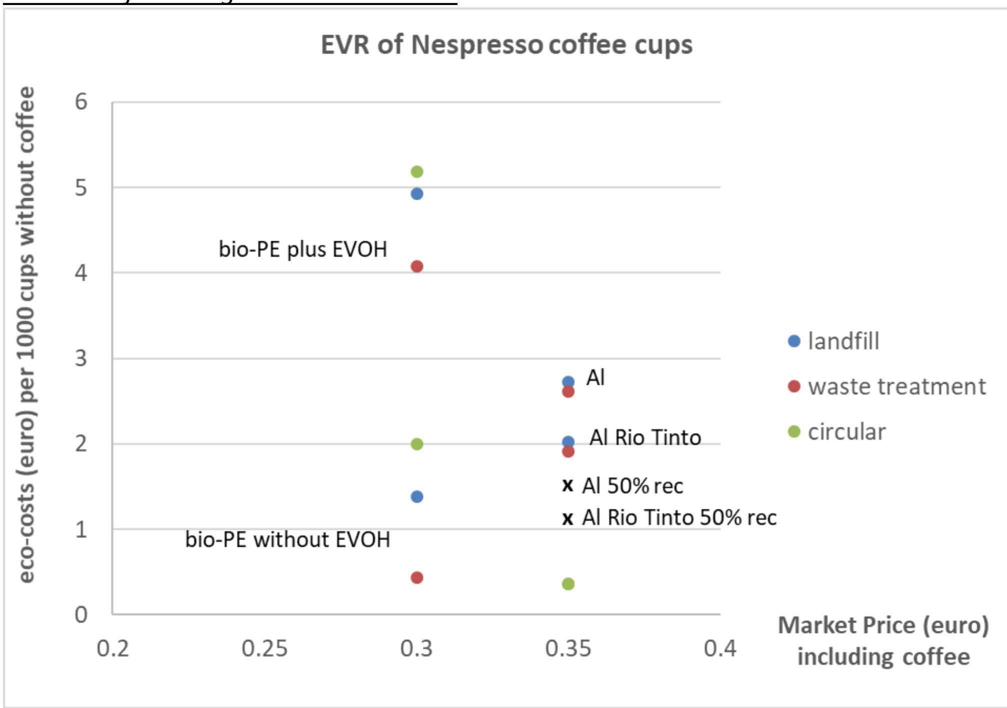
Note: The fastest data source is the app, however, the app has no data for the virgin Rio Tinto Al (from hydropower). Make a correction by hand: - 0.7 euro per kg). 100% recycled Al would score better, but is not allowed for food?

Note: The -0.7 correction must **not** be applied to the recycled Rio Tinto AL.

The data

	Aluminium 50% recycled	Aluminium virgin 'Rio Tinto'	bio-PE plus EVOH	bio-PE without EVOH
weight	1 gram per cup	1 gram per cup	3.6 gram bio-PE 0.4 gram EVOH	4 gram per cup bio-PE
price	0.35 euro	0.35 euro	0.30 euro	0.35 euro
remark	take average of virgin and recycled	ecocosts - 0.70 euro for virgin	recycling hardly possible	+ steel storage container (?)

Check the following calculation results



The key question

Any other ideas that are better? Make your own calculation and put it in the matrix.

You may read for additional information on Eco-efficient Value Creation:

Vogtländer et al. Eco-efficient Value Creation, sustainable strategies for the circular economy. Second edition, 2014. Delft Academic Press (VSSD Publishers), Delft.

Appendix A: URLs of videos

Module 1, Block 1: LCA, Introduction	https://youtu.be/LNsYtnXalio
Module 1, Block 2: LCA, the Basics	https://youtu.be/bXjy8H2bef0
Module 1, Block 3: LCA, cradle-to-cradle	https://youtu.be/UX0Aeh966OU
Module 2: Critical Raw Materials and LCA	https://youtu.be/xw8xXtampsk
Module 3: Circular Business Model canvas	https://youtu.be/mwfTJwbNFW0
Module 4, Block 1: Eco-efficient Value Creation (EVC)	https://youtu.be/Rn2kGXafD8I
Module 4, Block 2: EVC, exercise and assignments	https://youtu.be/L3lFxqVNWk8

URL Playlist INNOMAT

https://www.youtube.com/playlist?list=PLt1tc8_TsP8Q6YoSW_tVVGgnlSFKXp8Hs