

Life cycle costing in SimaPro

What is life cycle costing (LCC) and how can you perform LCC in SimaPro

SimaPro



PRé

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Introduction to life cycle costing (LCC)

The three types of LCC



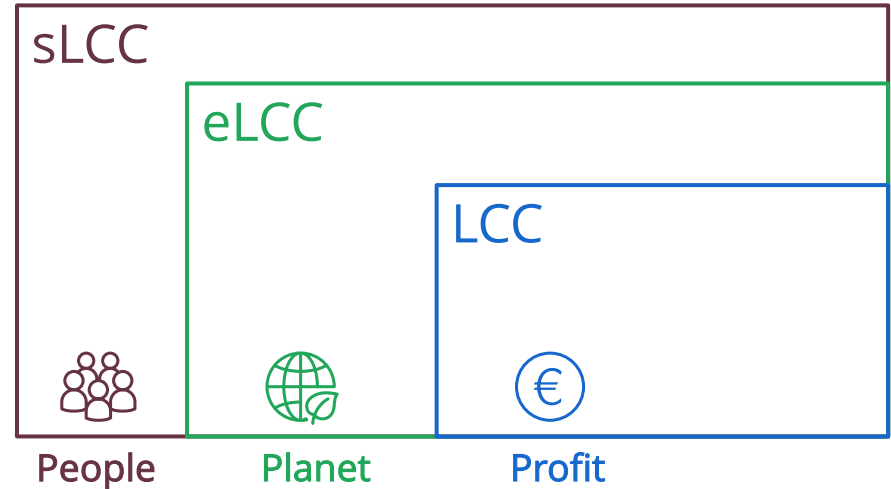
There are three types of life cycle costing:

- conventional LCC
- environmental (eLCC)
- societal (sLCC)

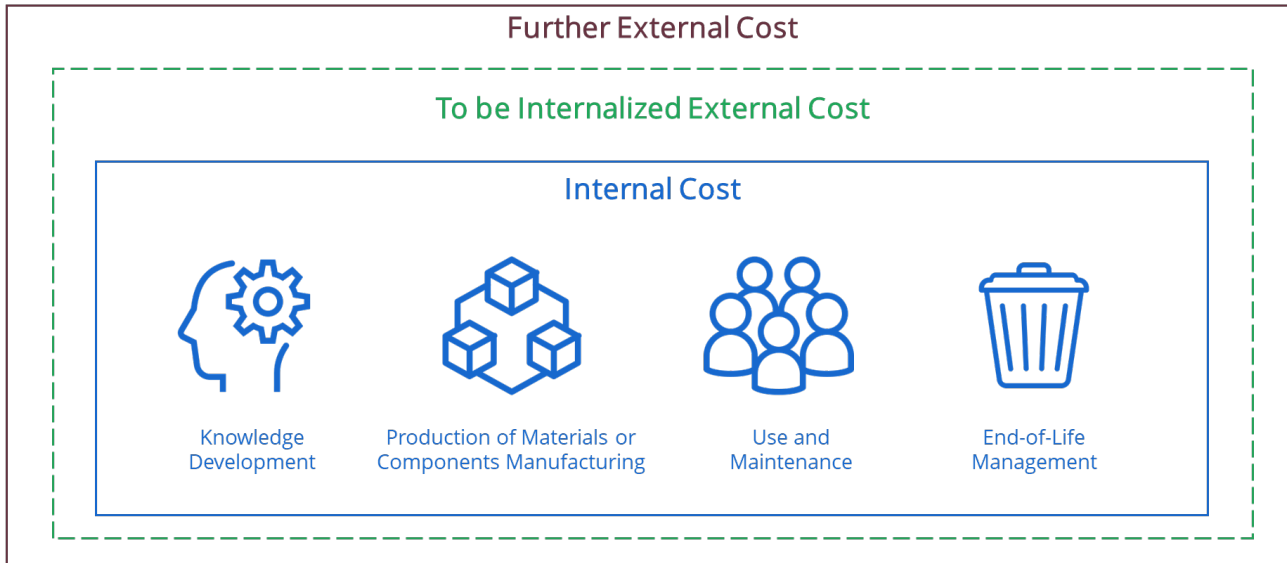
Conventional LCC, also termed financial LCC, is the original method, and in many ways synonymous with Total Cost of Ownership (TCO).

Environmental LCC is aligned with LCA in terms of system boundaries, functional unit, and methodological steps.

Societal LCC includes monetarisation of other externalities, including both environmental impacts and social impacts.



The three types of LCC



Conventional LCC: Assessment of internal costs, mostly without EoL costs; no LCA.

Environmental LCC: Additional assessment of external costs anticipated to be internalized in the decision relevant future; plus LCA in societal = natural boundaries.

Societal LCC: Additional assessment of further external costs.

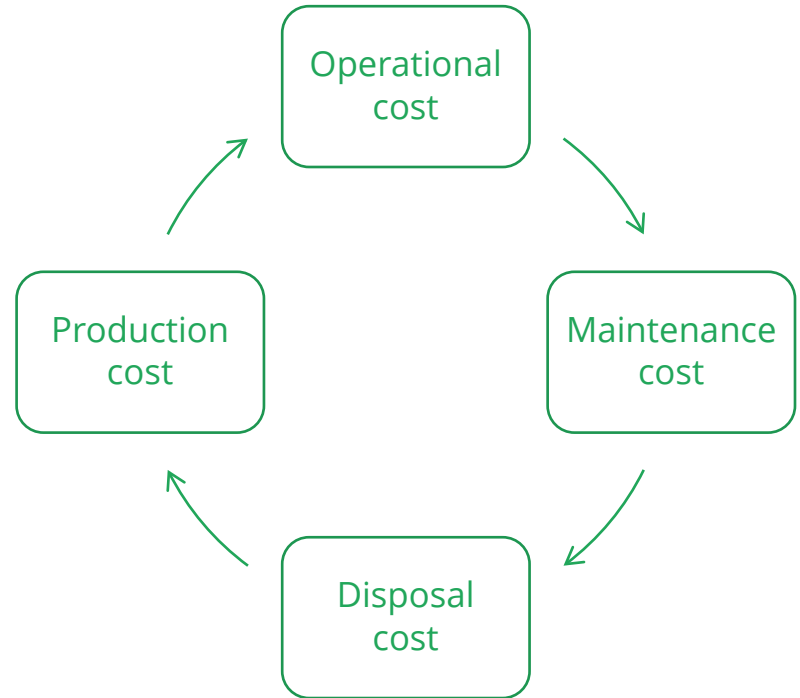
What is life cycle costing (LCC)?



Life cycle costing is an assessment of all costs related to a product or service over the entire life cycle from production over use until disposal.

It's especially relevant for those products that have a long lifetime and/or high maintenance, use or disposal costs.

Motivation to do LCC comes from both the user and the producer, industry-driven.



LCC can include positive and negative costs



Cost (price) is the monetary value that someone has to pay for something.



Revenues (negative costs) can also be included, as long as it is clear how it is being carried out.

- May be required to effectively support decision making, context dependent.
- Often left out for practical reasons.
- In case of multiple target groups (e.g. manufacturer and user of a car) adding revenues can be confusing, as the cost for one actor is often the revenue for another.

LCC can include internal and external costs



- Internal costs ('private'): borne by actors directly involved in the life cycle.
- External costs ('externalities'): value changes caused by a business transaction, which are not included in its price, or value changes caused as side effects of the economic activity.
- In conventional LCC external costs are usually not included.
- Conventional LCC is done from the perspective of a single actor, often the user of a solution.

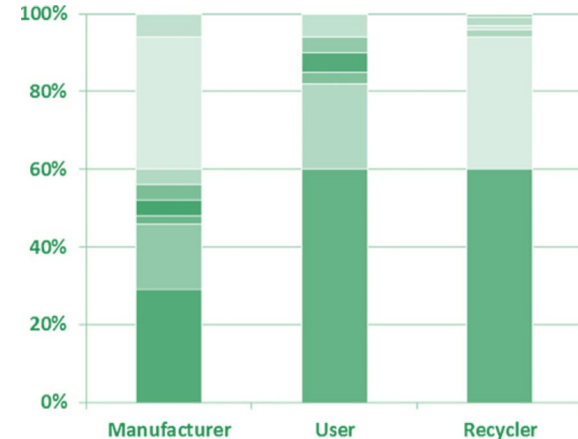


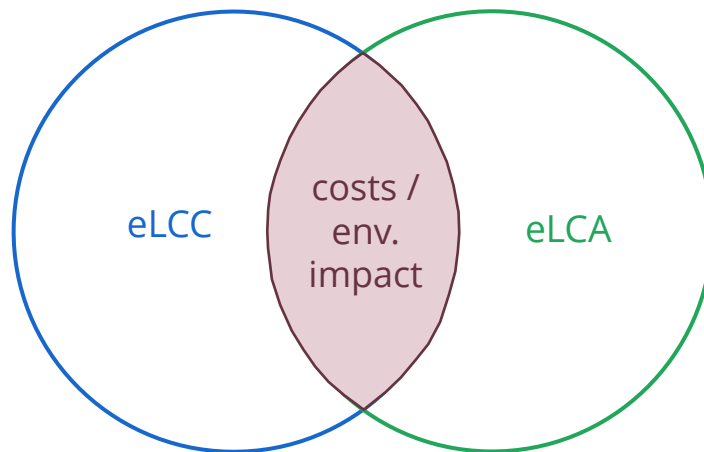
Image source: Rödger, Laumann Kjær and Pagoropoulos (2017) LCC: An Introduction. In: Hauschild, Rosenbaum and Olsen (Eds) *LCA Theory and Practice*. Cham (CH): Springer. 373-400.

LCC combined with LCA is part of many eco-efficiency approaches



When doing both, be careful:

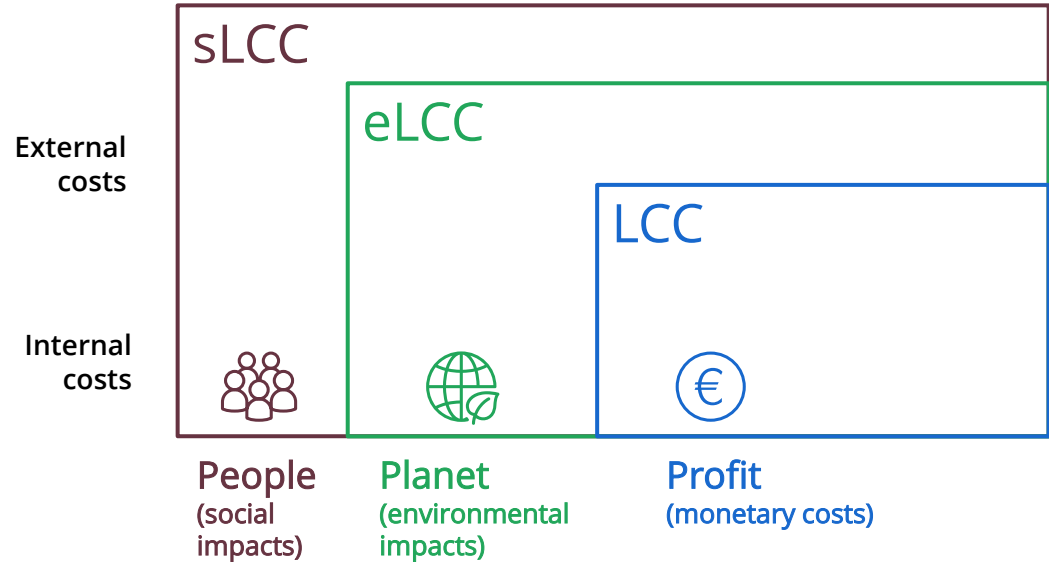
Including external costs in LCC from environmental impacts that are monetarized in the LCA will result in double counting.



Stepwise approach to include externalities



Social LCC (sLCC) goes one step further and monetarizes social impacts such as affected social well-being, job quality, etc.



Source: Rödger, Laumann Kjær and Pagoropoulos (2017) LCC: An Introduction. In: Hauschild, Rosenbaum and Olsen (Eds) *LCA Theory and Practice*. Cham (CH): Springer. 373-400.

Combining life cycle costing and life cycle assessment

Combining LCC with LCA



Environmental LCC (eLCC) was developed to support environmental life cycle assessment (eLCA): it covers the economic dimension and helps identify hotspots in both cost and environmental impacts.

eLCC is aligned with eLCA, and the steps are the same:

1. Goal and scope definition
2. Data collection
3. Impact assessment
4. Interpretation and sensitivity analysis

Goal and scope



Goal and scope: clearly defined and aligned with eLCA.

Functional unit: defined in similar way as eLCA, if conducted in parallel then it should be equivalent.

System boundaries: must be clearly defined, documented, equivalent and assume the same user perspective. eLCC analysis could be coarser.

Cut-off criteria: different for eLCA and eLCC.

- eLCA leaves out processes that are assumed to have a negligible contribution thus introducing cut-offs.
- LCC not applicable, as costs that occur upstream in the supply chain are assumed to be represented in the price of a product or a service.

Allocation: different for eLCA and eLCC

- eLCA multi-output allocation or system expansion
- LCC system expansion is not performed → exception: overhead costs

Inventory and data collection for eLCC



Simply adding costs of all actors in the life cycle would not yield any meaningful result:

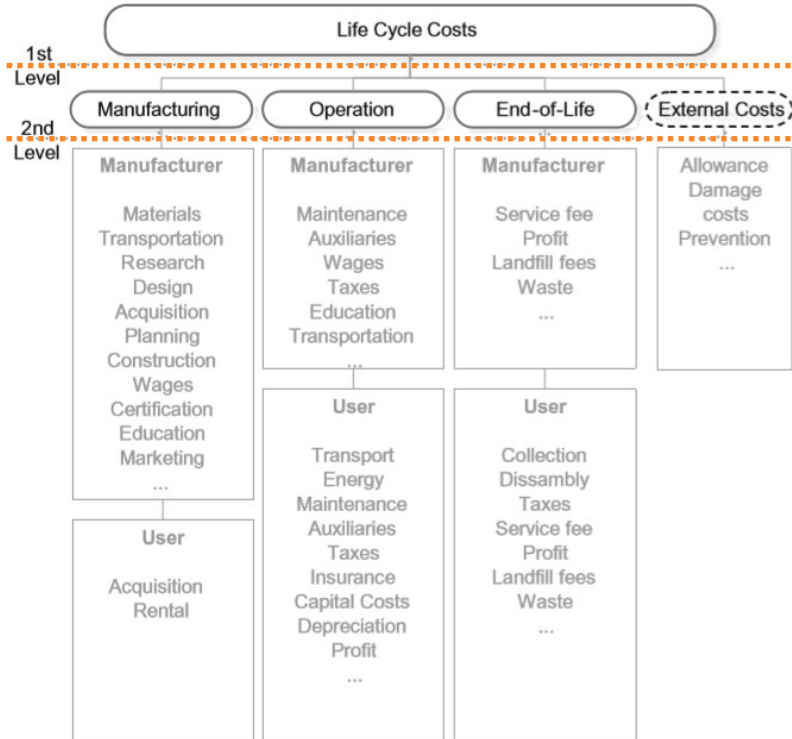
$$\begin{array}{ccccc} \text{Cost of one} & & \text{Revenue of} & & \text{Aggregating} \\ \text{actor} & + & \text{another actor} & = & \text{the same cost} \\ & & & & \text{multiple times} \end{array}$$

Instead, consider the value added at each stage of the life cycle:

$$\begin{array}{ccccc} \text{Sales of} & & \text{Purchase of products} & & \text{Value} \\ \text{products} & - & \text{(incl. labor + capital costs)} & = & \text{added} \\ \text{(incl. profits)} & & & & \end{array}$$

Costs should be quantified in one currency (e.g., euro or US dollar) for one reference year (e.g., Euro2015).

Use cost categories on different aggregation levels



Example: Car LCC

To get an overview of the hotspots of the assessed product systems, it is recommended to use cost categories on different aggregation levels. The 1st level consists of three life cycle stages (Manufacturing, Operation and End-of-Life) and external costs. For a manufacturer, the main objective is to analyse every cost in detail during manufacturing, thus the level of detail is higher compared to the other stages in the life cycle. For a user, the focus is on the different costs during the use of the product or service. This affects the data collection strongly.

To make the data collection more applicable, it should be distinguished between the user perspective and the manufacturer perspective thus each life cycle stage has several sub-categories at the second level.

Data collection for eLCC



Company-based data: time consuming, depends on collaboration of various departments/actors

- Internal: Finance, production, R&D departments
- External: industry databases, national statistics

Independent data sources: public databases, research paper or other studies, different scopes

Indirectly derived data: cost estimation techniques

- Expert opinions, surveys and interviews, estimates, etc.

Public databases for life cycle cost data



| Type | Scope | Name | Link |
|-------------------------|---------------------------|-----------------------------------|---|
| Crude oil | Sectors, monthly, country | International Energy Agency | https://www.iea.org/data-and-statistics/data-product/oced-energy-prices-and-taxes-quarterly#overview |
| Plastics | Global, weekly | The Plastic Exchange | www.theplasticsexchange.com |
| Marine fuel oils | Sector, daily, global | Ship and Bunker's | www.shipandbunker.com/prices |
| Chemicals | Sector, daily, global | ICIS, Part of RELX Group | https://www.icis.com/explore/about/methodology/ipex-methodology/?intcmp=mega-menu-explore-about-methodology-ipex-methodology |
| Metals | Sector, daily, global | London Metal Exchanges | www.lme.com |
| Commodities | Sector, yearly, global | United Nations | https://comtrade.un.org/ |
| Inflation | Sector, country, monthly | World Bank | https://data.worldbank.org/ |
| Wages | Sector, country, yearly | International Labour Organization | www.ilo.org |
| Currency exchange rates | Yearly, monthly | World Bank | https://data.worldbank.org/ |
| Power, gas, coal, oil | Daily | European Stock Exchange | www.eex.com/en |

! Not included in SimaPro!

Be careful with temporal aspects

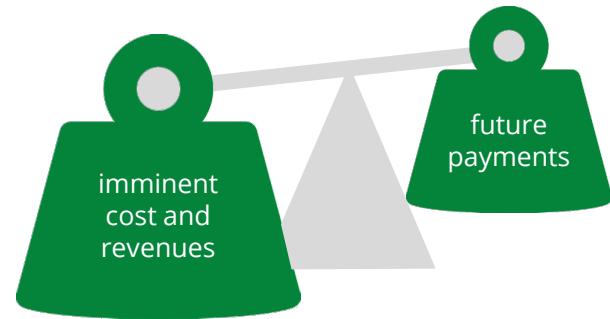


Monetary flows occur at different times. This complicates the analysis:

1. Prices change due to the market dynamics

In LCC one would like to compare costs based on a chosen reference year. All costs needs to be adjusted to that year.

2. People may have a time preference: they may prefer to spend money later rather than now. This can be taken into account with the use of discounting (lower weight to future payments).



Life cycle costing in SimaPro

SimaPro

The background features several white, curved, abstract lines that sweep across the green field, creating a sense of movement and design.

Is SimaPro suitable for LCC?



- **LCC can be performed in SimaPro**
 - As a stand-alone analysis
 - Especially, together with an (environmental) LCA
- LCC is straightforward to implement and use. LCC with more advanced elements is possible with workarounds:
 - Discounting
 - Dealing with cost fluctuations and cost uncertainties
- So far, costs are only available in input/output databases:
 - As prices for product flows, thus of limited value for LCC.



1. Creating a new method for LCC



The screenshot shows the SimaPro software interface. The main window is titled 'Edit method 'LCC V1.00''. The 'General' tab is selected, displaying the following fields and options:

- Name: LCC
- Version: 1.00
- Structure: Damage assessment, Normalization, Weighting, Addition
- Comment: (empty text area)

The 'Normalization' checkbox is highlighted with an orange box. A green text box is overlaid on the dialog, containing the following instructions:

- Create a new method and fill in the name and details under the tab General.
- Deselect "Normalization", as normalization is not (commonly) applied in LCC.

The left sidebar shows the 'LCA Explorer' tree with 'Methods' highlighted under 'Impact assessment'. The right sidebar shows a list of actions: New, Edit, View, Copy, Delete, Used by, Check, and Set as default. The 'New' button is highlighted with an orange box.

1.1 Add impact categories



Edit method 'conventional LCC V1.00'

| General | | Characterization | | Damage assessment | | Weighting | |
|-----------------|---------|------------------|---------|---------------------|-----------|-----------|--------------|
| Impact category | Unit | Compartment | Subcorr | Substance | CAS numbe | Factor | Unit |
| Personnel cost | EUR2018 | Economic | | Education | | 42 | EUR2018 / hr |
| Material cost | EUR2018 | Economic | | Installation labour | | 35 | EUR2018 / hr |
| Revenue | EUR2018 | Economic | | Production labour | | 22 | EUR2018 / hr |
| Assembly | EUR2018 | Economic | | Recycling labour | | 20 | EUR2018 / hr |
| Transport | EUR2018 | | | | | | |
| Use | EUR2018 | | | | | | |
| Maintenance | EUR2018 | | | | | | |

Add **Delete** **Add** **Delete** **Find text** Items

- Add types of cost and their currency under “Impact categories”.
- Add subcategories (substances) as economic issues, select an appropriate unit, and click OK.

New economic issue

Name
Education

Quantity Default Unit CAS number
Time hr

Comment

OK **Cancel**

1.2 Specify the damage assessment



Edit method 'LCC V1.00'

| General | | Characterization | | Damage assessment | Weighting |
|-----------------|---------|------------------|--------|-------------------|-----------|
| Damage category | Unit | Impact category | Factor | Unit | |
| Fixed costs | EUR2018 | Material cost | 1,1 | EUR2018 / EUR2018 | |
| Variable costs | EUR2018 | Transport | 1,25 | EUR2018 / EUR2018 | |
| Revenue | EUR2018 | Assembly | 1,1 | EUR2018 / EUR2018 | |
| | | Maintenance | 1,1 | EUR2018 / EUR2018 | |
| | | Use | 1,1 | EUR2018 / EUR2018 | |

- Define top level cost categories (damage categories)
- Assign the existing cost categories to the damage categories - specify also a unit and a conversion factor

Add **Delete** **Add** **Delete** **Save** **Close**

1.3 Specify the weighting



Weighted score Quantity Indicator Unit Pt

| Normalization/weighting set | Damage category | Weighting |
|-----------------------------|-----------------|-----------|
| Weighting 2018 | Fixed costs | 1,0 |
| | Variable costs | 1,0 |

- Define how to aggregate the top-level cost categories (damage categories).
- Value of "1" for simple addition of all cost categories - often a useful approach.
- For discounting or increasing prices, see steps 6 and 7.
- When you click "Save" your method is ready for use!

Add Delete Save Close

2. Editing specified costs



The screenshot shows the LCA Explorer interface. On the left is a navigation tree with categories like Inventory, Impact assessment, Interpretation, and General data. The 'Substances' category is selected. The main area displays a table of substances with columns for Substance, Default unit, and CAS number. The 'Window pane' row is highlighted in yellow.

| Substance | Default unit | CAS number |
|--------------------------|--------------|------------|
| Electricity | MJ | |
| Installation labour | hr | |
| Production labour | hr | |
| Recyclers' working hours | hr | |
| Train | tkm | |
| Truck | tkm | |
| Window frame | kg | |
| Window packaging | kg | |
| Window pane | kg | |

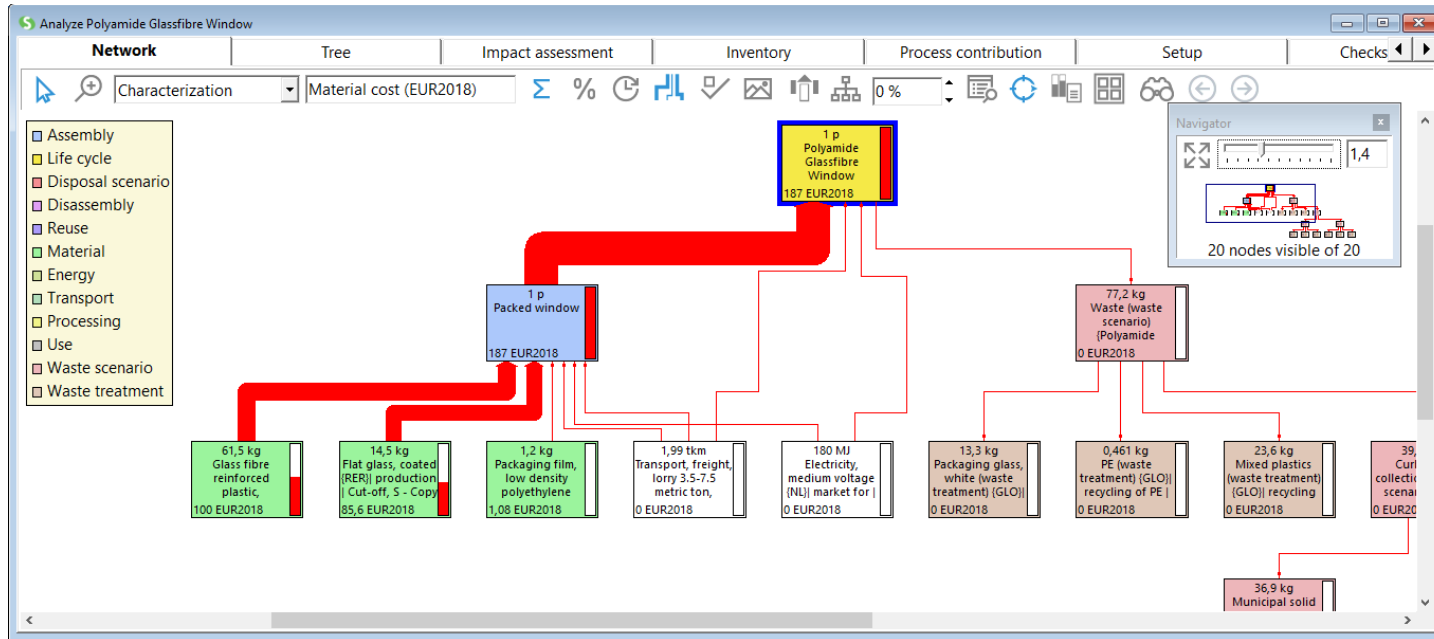
Editing economic issues can be done via "Substances".

3. Modeling the LC with cost information: adding economic issues to processes

• Create a new process with a link to the library item that includes the environmental substances and scroll down the Input/output sheet.
 • Add Economic issues.
 • Make sure to use the process incl. the economic issues in your project.

| Economic issues | Subcompartment | Amount | Unit | Distribution | SD2 or 2SD | Min | Max |
|-------------------|----------------|------------------|------|--------------|------------|-----|-----|
| Production labour | | $4/14,5 = 0,276$ | hr | | | | |
| Window frame | | 1 | kg | Undefined | | | |
| Electricity | | $7/14,5 = 0,483$ | MJ | | | | |

4. Calculating life cycle costs



Once the life cycle with cost information is modeled and the LCC method is specified, calculating LCC can be done like any other method. Simply select your LCC method in the calculation setup and press "Calculate"

5. Combining with external costs



- Monetarized LCIA methods in SimaPro:
 - Environmental Priority Strategies (EPS)
 - Stepwise: csv file available via 2.-0 LCA consultants (click [here](#))
 - Environmental Prices by CE Delft: Coming up in SimaPro 9.1!
- Combining LCC with external costs could be done by merging two methods.

5. Combining with external costs



Ctrl+C

Ctrl+V

| General | | Characterization | | Damage assessment | |
|-----------------|---------|------------------|--------|-------------------|--|
| Damage category | Unit | Impact category | Factor | Unit | |
| Fixed costs | EUR2018 | Material cost | | | |
| Variable costs | EUR2018 | Assembly | | | |
| Revenue | EUR2018 | Transport | | | |
| | | Use | | | |
| | | Maintenance | | | |

| General | | Characterization | | Damage assessment | |
|-----------------|---------|------------------|--------|-------------------|--|
| Damage category | Unit | Impact category | Factor | Unit | |
| External costs | ELU | | | | |
| Internal costs | EUR2018 | | | | |
| Revenue | EUR2018 | | | | |

- Combining your conventional LCC method with eLCA:
- Copy a monetarized LCIA method (e.g. EPS) and name it (e.g. 'combined')
 - Move all impact categories to one damage category: external costs
 - Copy the damage categories of the cLCC method one by one into the combined method

5.1 Including revenue



Revenue can be added as separate process to the LC.

Edit life cycle 'Polyamide Glassfibre Window'

Input/output Parameters

| Name | Status | Comment |
|-----------------------------|--------|---------|
| Polyamide Glassfibre Window | None | |

| Assembly | Amount | Unit | Distribution | SD2 or 2SD | Min | Max | Cc |
|---------------|--------|------|--------------|------------|-----|-----|----|
| Packed window | 1 | p | Undefined | | | | |

Processes

| Processes | Amount | Unit |
|--|-------------------------------|------|
| Transport, freight, lorry 3.5-7.5 metric ton, EURO4 [GLO] market for Cut-off, S - Co | $(61,5+14,5+1,2)*25 = 1,93E3$ | kgkm |
| Electricity, medium voltage [NL] market for Cut-off, S - Copy for LCC project | 15 | MJ |
| Polyamide Glassfibre Window sold | 1 | p |

Edit use process 'Polyamide Glassfibre Window sold'

Documentation Input/output Parameters System description

Products

| Outputs to technosphere: Products and co-products | Amount | Unit | Quantity |
|---|--------|------|----------|
| Polyamide Glassfibre Window sold | 1 | p | Amount |

Outputs to technosphere: Avoided products

| Amount | Unit | Distribution | SD2 or 2SD | Min |
|--------|------|--------------|------------|-----|
| | | | | |

Inputs

| Economic issues | Sub-compartment | Amount | Unit | Distribution |
|------------------|-----------------|--------|---------|--------------|
| Sales of product | | 900 | EUR2018 | Undefined |

Outputs to technosphere: Waste and emissions to treatment

| Amount | Unit | Distribution | SD2 or 2SD | Min |
|--------|------|--------------|------------|-----|
| | | | | |

5.1 Including revenue



Edit method 'combined eLCC & cLCC v1.00'

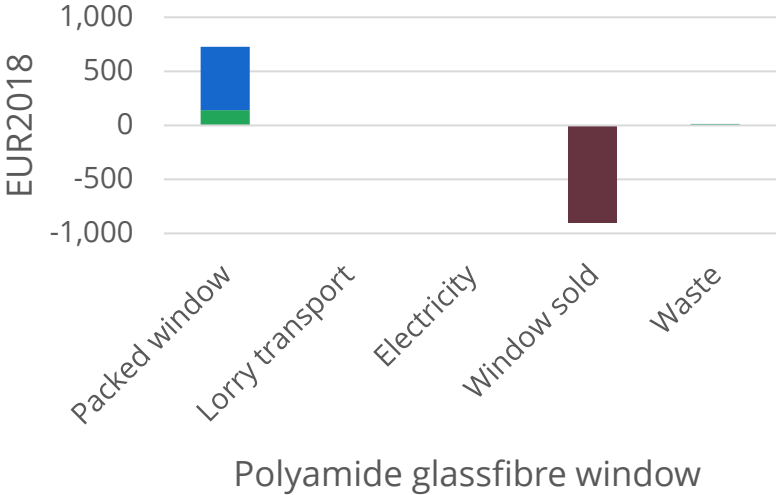
General **Characterization** Damage assessment

| Impact category | Unit | Compartment | Subcorr | Substance | CAS number | Factor |
|--------------------------|----------|-------------|---------|------------------|------------|--------|
| Low vision | PersonYr | Economic | | Sales of product | | -1 |
| Poisoning | PersonYr | | | | | |
| Intellectual disability: | PersonYr | | | | | |
| Osteoporosis | case | | | | | |
| Renal dysfunction | case | | | | | |
| Housing availability | m2 | | | | | |
| Separations | case | | | | | |
| Depletion of abiotic r | kg | | | | | |
| Personnel cost | EUR2018 | | | | | |
| Material cost | EUR2018 | | | | | |
| Revenue | EUR2018 | | | | | |
| Assembly | EUR2018 | | | | | |
| Transport | EUR2018 | | | | | |
| Use | EUR2018 | | | | | |
| Maintenance | EUR2018 | | | | | |

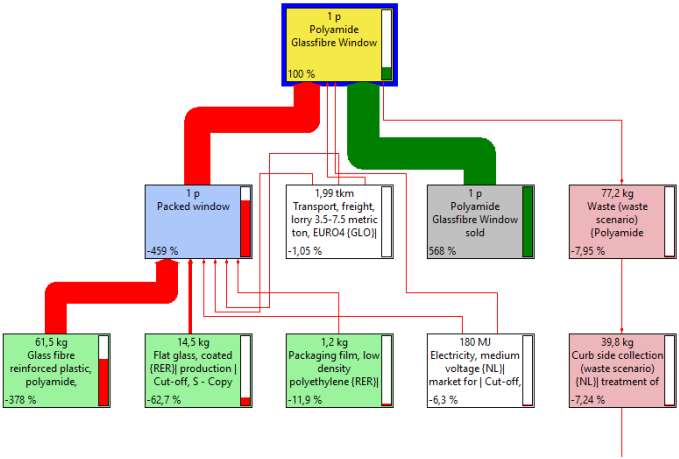
Buttons: Add, Delete, Find text, Items: 1, Total item, Save, Close

Revenue has a negative characterization factor

5.2 Combining revenue, internal, and external costs



- Revenue
- Internal costs
- External costs



6. Dealing with cost fluctuations

- Costs and revenues can vary strongly, in contrast to regular characterization factors for impact assessment.
- A natural way to deal with this, would be to add uncertainty to the economic issues (characterization factors). This is not possible in SimaPro.

Workaround:

- Add uncertainty at process level.
- Take care when transferring the probability distributions from the costs-per-mass to mass, in view of a difference in data level.

6. Dealing with cost fluctuations



| Documentation | Input/output | Parameters | System description | | | | |
|----------------------|--------------|--------------|--------------------|-----|-----|--------------------------|------------------|
| Input parameters | Value | Distribution | SD2 or 2SD | Min | Max | Hide | Comment |
| Costfluc | 1 | Normal | 0,06 | | | <input type="checkbox"/> | Costfluctuations |
| Add line | | | | | | | |
| Calculated parameter | Expression | Comment | | | | | |
| Add line | | | | | | | |

- Specify the uncertainty in a parameter.
- Multiply the economic issue with this parameter.
- If desired, you can move the parameter up to project level via right click – “Move Parameter”.

Edit material process 'Glass fibre reinforced plastic, polyamide, injection moulded [RER] production | Cut-off, S - Copy for LCC project'

| Documentation | Input/output | Parameters | System description |
|--|--------------|----------------|---------------------------------------|
| Add line | | | |
| Non material emissions | | Subcompartment | Amount Unit Distribution SD2 or 2SD M |
| Add line | | | |
| Social issues | | Subcompartment | Amount Unit Distribution SD2 or 2SD M |
| Add line | | | |
| Economic issues | | Subcompartment | Amount Unit Dis |
| Production labour | | | 4/14,5*Costfluc = 0,276 hr |
| Window frame | | | 1 kg Un |
| Electricity | | | 7/14,5 = 0,483 MJ |
| Add line | | | |
| Outputs to technosphere: Waste treatment | | Amount Unit | Distribution SD2 or 2SD M |
| Add line | | | |

7. Discounting

Discounting is a topic for debate for studies in which LCC and LCA are done in parallel. Discounting is usually done in LCC, but rarely done in LCA.

In SimaPro, discounting can be included via **weighting**:

- Instead of aggregation damage categories with a factor of 1 (as done in section 1.3), the factor should express the discounting
- Discount factor needs to be calculated outside of SimaPro and documented in the comment field of the weighting factor

$$w(t) = \frac{1}{(1+r)^t}$$

Discount factor is the weight $w(t)$ for payments occurring at time t

Discount factor depends on the discount rate r , which is the rate by which the discount factor decreases over time assuming a first order decrease

Glossary of terms



| Term | Definition |
|----------------|---|
| Price | The amount of money that will purchase a finite quantity, weight, or other measure of a good or service (Sullivan et al. 2006) |
| Revenue | The income generated from sale of goods or services, or any other use of capital or assets, associated with the main operations of an organization before any costs or expenses are deducted. |
| Internal costs | Costs borne by actors directly involved in the life cycle of the system under study. |
| External costs | External costs (also termed externalities) are value changes caused by a business transition, which are not included in its price, or which occur as side effects of economic activity (Dodds and Galtung 1997; Hunkeler et al. 2008) |
| Value added | Value added is the difference between the sales of products and the purchases of products or materials by a firm, covering its labor costs and capital costs as well as its profits (Hunkeler et al. 2008) |

Glossary of terms



| Term | Definition |
|-------------------------|--|
| Life cycle costs | The sum of value added over the life cycle of a product or a system (Moreau and Weidema 2015) |
| Net Present Value (NPV) | NPV is the sum of all the discounted future cash flows that takes into account the time value of money over the entire life time (Park 2011) |
| Discounting | A method used to convert future costs or benefits to present values using a discount rate (Langdon 2007) |
| Inflation rate | A measure of the overall change in prices for goods and services over time |
| Exchange rate | Currency conversion between different currencies |

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