

# Life Cycle Costing and calculation of Value Added in openLCA



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## 1 Life Cycle Costing, and the concept of Value Added

**Life Cycle Costing** (LCC) has the aim to assess the costs of a product over its entire life cycle. Since its first emergence in the 1930's, LCC has been applied in many different cases worldwide, and is now a commonly used approach for example in procurement of long-living goods, in many industrial sectors. Often, sectors or also larger companies have developed a specific LCC approach, with specific cost categories, and cost aggregation rules for example (Ciroth James 2008).

For LCA, a SETAC Working Group published a book and code of practice for “Environmental LCC” with the aim to present a method that is consistent with LCA, and that can be conducted together with (environmental) LCA in an efficient manner (Hunkeler et al. 2008, Swarr et al. 2011).

Costs are typically seen as the monetary value of goods and services that are purchased by producers or consumers ( e.g. Eb 2016), and can usually be referred to a price that is paid for a product or service. The concept of **Value Added** is similar to life cycle costing, but looks on the positive side: for a reasonable production process, costs spent are lower than the price that can be achieved by selling the created product(s); the process is creating value. The added value of a process is the difference between the costs spent and the price achieved by selling the created product or products. While traditionally more in use in investment decision support, Heijungs et al. (2013) and Moreau and Weidema (2015) have proposed and used it for environmental LCC.

## 2 LCC and Value Added in openLCA

The implementation in openLCA follows the proposal of the SETAC working group, for costs, with some modifications, as follows:

- costs are modelled as properties of exchanges, i.e. of inputs and outputs of processes;
- costs can be positive or negative; negative costs are added value
- costs are displayed in the process editor, in a new column for the exchanges;
- when a product system is calculated, both costs and added value are available, in parallel to inventory and impact assessment results

Value added builds on this concept, taking value added as “negative costs”, i.e. reversing the sign. Thereby, the value added implementation follows recent proposals from Moreau Weidema 2015, Heijungs et al 2013.

## 2.1 A closer look at how costs are specified in the process editor

Starting point for the cost model and LCC calculation in openLCA are the costs for process data sets. In the process editor, costs can be entered for each exchange, i.e. for each input and output, of a process. Both costs and revenues can be considered.

P Production of chair ☒

**Process: Production of chair**

▼ Inputs

Flow	Category	Amount	Unit	Costs	Uncertainty
Fe Electricity		2.0	MJ	10.0 USD	none
Fe Wood		5.0	kg	5.0 USD	none

▼ Outputs

Flow	Category	Amount	Unit	Costs/Revenues	Uncertainty
Fe Chair		1.0	Item(s)	25.0 USD	none

Figure 1: Costs and revenues for exchanges, example process data set, openLCA 1.5

Costs on the input side are costs. On the output side, for products, amounts in this column are revenues (the product is sold), while release of elementary or waste flows might cause a cost, e.g. release of CO<sub>2</sub> or emission of waste water with heavy metals. Therefore, any positive amount entered for a product on the output side refers to revenue, while every positive amount entered for an elementary flow reflects costs. To help distinguish both, costs are shown in purple, while revenues are shown in green (Figure 1).

To edit the costs, or to enter new costs, click in the cost column, and click on edit (Figure 2).

Amount	Unit	Costs/Revenues	Uncertainty
1.0	Item(s)	25.0 USD	none
0.12	kg		none

Edit

Figure 2: Entering or editing costs, process editor, Inputs/outputs sheet, openLCA 1.5

A new window will appear for specifying the currency and the amount costs. The amount is meant to be entered as absolute value, i.e. as costs for the amount of the exchange as it is entered for the exchange; for the example in Figure 2, it is the costs for 0.12 kg. The costs per specified unit, e.g. per kg, are calculated automatically; they are shown in the small window for entering costs which opens when clicking on edit in the cost/revenue column.

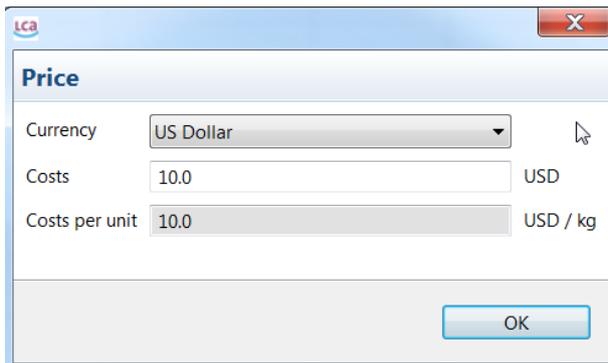


Figure 3: Entering or editing costs, detail window, with absolute costs (costs for the amount specified for the exchange) and costs per unit which are calculated, openLCA 1.5

## 2.2 Currencies

As shown in the figures above, costs are expressed in currencies. It is possible to switch for a cost entry between different currencies in the detailed cost window (Figure 4). All currencies available in a database can be found under background data, in the currencies folder (Figure 5). For an entire database, one currency is selected as reference, for the other currencies, an exchange rate is stored to allow recalculation of costs in another currency.

The exchange rates are used for calculating the conversion factors which are applied when different currencies in the process are selected.

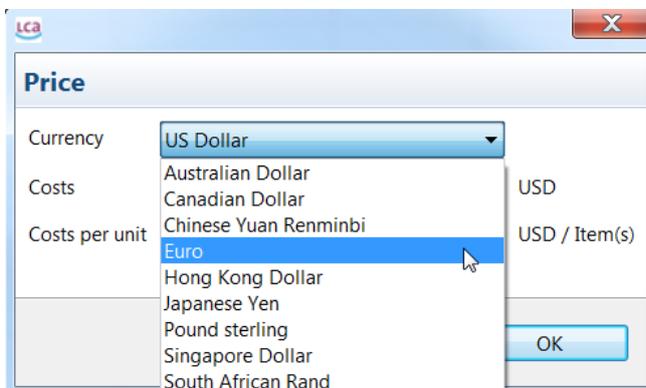


Figure 4: Entering or editing costs, process editor, Inputs/outputs sheet, openLCA 1.5



Figure 5: Currencies in openLCA 1.5

The reference currency can be changed within one currency (click on “set as reference currency?”, Figure 6).

**Cost category: Pound sterling**

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**General information**

Name: Pound sterling

Description: 2015 average. Source: <http://www.oanda.com>

Version: 00.00.000

UUID: 0b705d37-d71c-4c8f-8e02-2b36663635c6

Last change:

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**Additional information**

Currency code: GBP

Conversion factor: 0.6542999999999998

Reference currency: [\\$¥ US Dollar](#)

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**Other currencies**

Name	Code	Exchange rate
<a href="#">\$¥ Australian Dollar</a>	AUD	1 GBP = 0.491 AUD
<a href="#">\$¥ Canadian Dollar</a>	CAD	1 GBP = 0.512 CAD
<a href="#">\$¥ Chinese Yuan Renminbi</a>	CNY2	1 GBP = 0.105 CNY2
<a href="#">\$¥ Euro</a>	EUR	1 GBP = 0.726 EUR
<a href="#">\$¥ Hong Kong Dollar</a>	HKD	1 GBP = 0.084 HKD
<a href="#">\$¥ Japanese Yen</a>	JPY	1 GBP = 0.005 JPY
<a href="#">\$¥ Singapore Dollar</a>	SGD	1 GBP = 0.476 SGD
<a href="#">\$¥ South African Rand</a>	ZAR	1 GBP = 0.051 ZAR
<a href="#">\$¥ Swedish Krona</a>	SEK	1 GBP = 0.078 SEK
<a href="#">\$¥ Swiss Franc</a>	CHF	1 GBP = 0.68 CHF

Figure 6: Currency in openLCA 1.5



When changing the reference currency, all open currency editors will be closed for updating the conversion factors, and the editor of the new reference currency will be opened again.

### 2.3 Multi-output processes

Allocation of costs: In case of multi-output processes in the database it is important to know what happens to the costs of by-products during the calculation of a product system. You have different options for setting the allocation method in the calculation properties. Depending on this choice (and depending on what is defined in the processes itself) the following rules will be applied:

- When “none” is selected as allocation option in the calculation properties, all costs are considered (the price of the by-product as revenue)
- When “physical”, “causal” or “economic” is selected as calculation property for allocation, the allocation factors are applied to the exchanges and the price of the by-product is not considered
- When “As defined in processes” is selected:
  - and physical, causal or economic allocation is chosen in the processes, again the allocation factors are applied to the exchanges and the price of the by-product is not considered
  - and no allocation (“none”) is selected in the processes, all costs except the one from the by-product are considered

If you want to apply system expansion, i.e. one of the output products is marked as “avoided product”, the calculation is as follows:

- When no allocation is selected in the calculation properties, the following formula is applied:

*Added value = Price Reference\_Product – Price elementary flows/inputs – Price ByProduct – Added value of avoided supply chain*

- When allocation is selected (e.g. “As defined in processes”), the following formula is used:

*Added value = Price Reference\_Product + Allocation\_factor\*(– Price elementary flows/inputs – Price ByProduct – Added value of avoided supply chain)*

Allocation of exchanges: Allocation works the same way as in previous version of openLCA with one additional rule for the economic allocation. In previous versions of openLCA it was already possible to define an economic flow property; this feature is still available in openLCA

1.5 which means that there are two places where to add an economic property for an exchange. It is assumed that the process-specific information is more precise, therefore the following rule is applied:

When economic allocation is selected and all output products have an economic value (revenue) defined in the process editor, those values will be taken. However, in the case that not all output products have a revenue defined, then the economic flow properties will be used for the calculation (if there are any).

### 3 A small case study example

As an example, a small case study will be presented in the following. The case study is taken from Moreau and Weidema (2015), who in turn refer to a publication by Heijungs and colleagues (Heijungs et al. 2013), and was rebuilt in openLCA.

The case study is about the life cycle of a wooden chair, the functional unit defined as sitting on the chair for ten years. Overall, the chair is assumed to have a life time of 2 years, which is quite short. The simplified life cycle consists of few processes only:

- production of wood
- production of electricity
- production of the chair
- usage of the chair
- disposal of the broken chair

Costs and material exchanges between these processes are shown in Table 1. Since the functional unit is 10 years of sitting, 5 chairs are required.

Table 1: Chair case study: Processes, physical exchanges, costs and value added (Moreau and Weidema 2015, modified)

Activity (process)	Product	Physical amount	Costs per unit*	Costs**	Value added
Production of electricity	Electricity	1 MJ	5 €/MJ	5 €	5 €
Production of wood	Wood	1 kg	1 €/kg	1 €	1 €
Production of chair -	Electricity	2 MJ	5 €/MJ	-10€	10 €
	Wood	-5 kg	1 € /kg	- 5 €	
	Chair	1 piece	25 €/piece	25 €	
Use of chair	Chair	5 pieces	25 €/piece	-125 €	-135 €* 2 €
	Broken chair	5 pieces	2 €/piece	-10 €	
	Sitting	10 years	0 €/year*	0 €* 2 €	
Disposal of broken chair	Broken chair	1 piece	- 2 €/piece	2 €	2 €

\*in Moreau and Weidema 2015: "price"; \*\*in Moreau and Weidema 2015: "monetary amount"

In openLCA, the processes have been created, and a product system has been built where these processes exchange their products, as described in the table (Figure 7). Note that the disposal (end of life) of the chair is modelled as provided service to the use of the chair, following the typical ecoinvent (and SimaPro e.g.) modelling of end of life treatment.

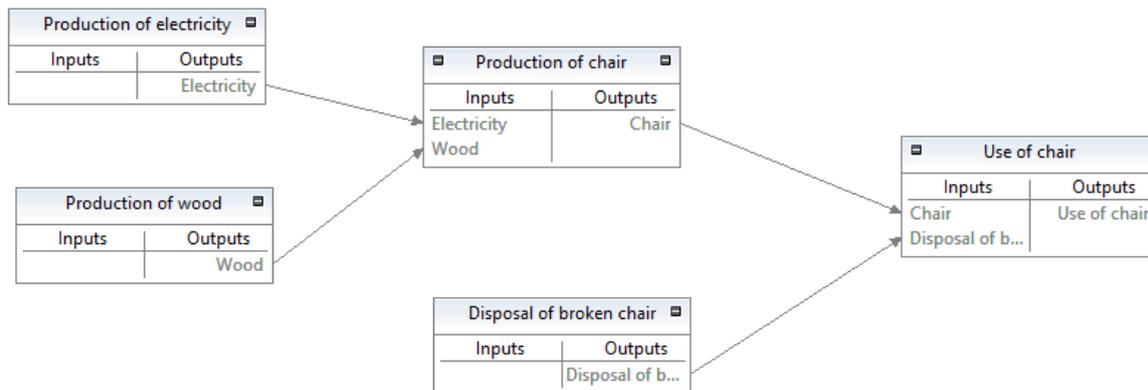


Figure 7: The created product system in the model graph in openLCA

One example for a process with costs is already shown in Figure 1, for the production of the chair.

When the product system is calculated, several summaries of results for costs and added value are available. For example, in the process contributions tab, a new section “costs/added values” is available, which shows the contribution of different processes to the final cost and added value result. It is possible to switch between costs and value added; costs are value added multiplied by -1, i.e. costs for input products “purchased” for one process, minus price of the generated products (Figure 8).

Costs/Added values				
Costs \$¥ Added value				
Cut-off 0 %				
Contribution	Process	Amount	Unit	
37.04%	Production of chair	50.00000	USD	
37.04%	Production of electricity	50.00000	USD	
18.52%	Production of wood	25.00000	USD	
07.41%	Disposal of broken chair	10.00000	USD	
00.00%	Use of chair	0.00000	USD	

Costs/Added values				
Costs \$¥ Net-costs				
Cut-off 0 %				
Contribution	Process	Amount	Unit	
00.00%	Use of chair	0.00000	USD	
-07.41%	Disposal of broken chair	-10.00000	USD	
-18.52%	Production of wood	-25.00000	USD	
-37.04%	Production of chair	-50.00000	USD	
-37.04%	Production of electricity	-50.00000	USD	

Figure 8: Costs and value added in the process contributions tab

For the production of the chair, for example, net costs are  $(5 + 10) \text{ €} - 25 \text{ €} = -10 \text{ €}$ ; for 5 chairs required in the product system, the amount is  $-50 \text{ €}$ .

In the contribution tree, value added and life cycle costs are available as new section, in addition to LCIA categories and elementary flows (Figure 9).

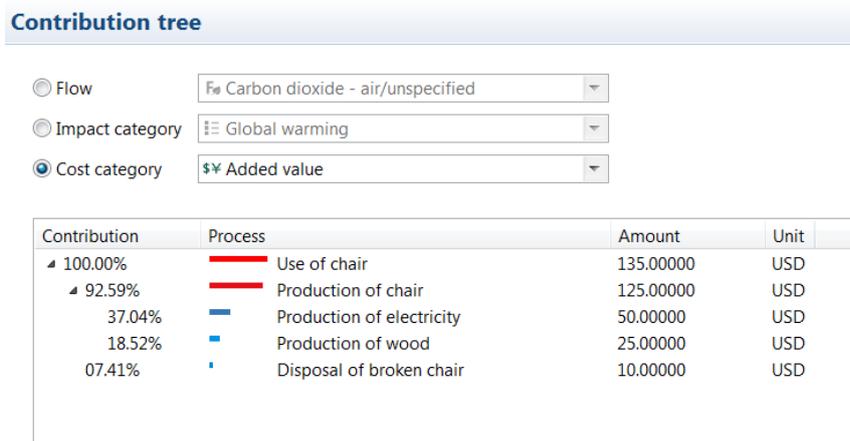


Figure 9: Costs and value added in the process result tab

The database with the case study is available for download here:

[http://www.openlca.org/case\\_studies](http://www.openlca.org/case_studies)

## 4 Summary and conclusion

A flow-based approach for calculating Life Cycle Costs and Value Added has been implemented in openLCA, which is in line with the Environmental LCC approach. This implementation replaces previous, process cost based approaches in openLCA. It is more flexible since it allows specification of separate costs for each exchange in a process.

Allocation of exchanges works as usual, with the exception that, as long as for every output product there is an economic value specified within the process, those values will be taken for economic allocation (instead of the economic flow properties as before).

Both Value Added and Net Costs can be calculated. Since both are closely related (according to Moreau, the life cycle costs are the sum of the value added), they provide the same information, and it is more up to the user to select the one that is more appropriate.

## 5 Feedback and contact

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