

# openLCA Tutorial Basic Modelling in openLCA

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#### 1 Introduction

openLCA is the open-source <u>software</u> for Life Cycle Assessment (LCA) and Sustainability Assessment, developed since 2006 by GreenDelta. As open-source software, it is freely available, e.g. from the project website (<u>openlca.org</u>), without license costs.

This text focuses on the 1.10 version of openLCA and explains basic modelling and environmental impact assessment in openLCA. This includes step-by-step instructions for modelling flows, processes, products systems and projects to quantify the environmental impacts of product systems and projects. Please note that this is not a comprehensive LCA, the example with LCA data given is for instructional purposes only.

The example given is based on the *ELCD database 3.2* which is available free of charge on the <u>Nexus web</u> repository.

To quantify the environmental impacts of the system modelled, the Impact assessment methods must be imported in openLCA. The LCIA methods *openLCA LCIA methods v2.0.4* are available on the nexus as well.

Information about how to import the *ELCD database* and the LCIA methods into openLCA can be found in the openLCA User Manual available in the Learning and Support section in the <u>openLCA website</u>.

The database bottle tutorial with all elements created within this tutorial can be downloaded here.

#### 2 **Basic Modelling**

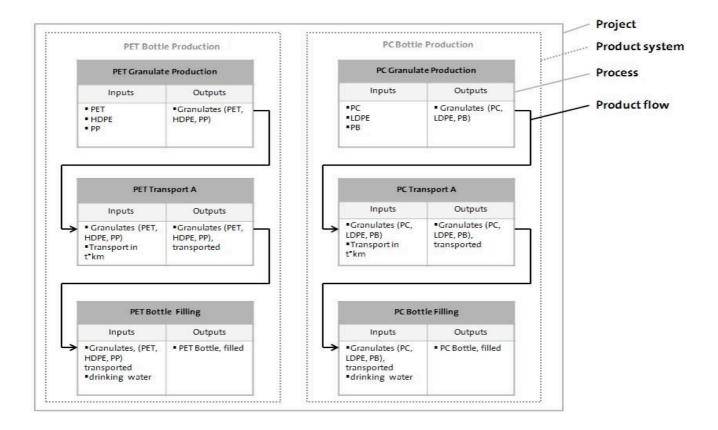
In this text, we will introduce basic modelling steps in openLCA using an example of plastic bottles for packaged drinking water. We will explore the environmental impact of producing a PET bottle as opposed to a PC bottle. The life cycle to be modelled is shown in Figure 1.

The database elements needed for modelling and comparison of product systems in openLCA are:

Ρ

F

- 1h Projects
- Product systems •
- Processes
- Flows



#### 3 Flows

Flows are all product, material or energy inputs and outputs of processes in the product system under study. A flow is defined by the name, flow type, and reference flow property. openLCA distinguishes three flow types:

- elementary flows: material or energy of the environment entering or leaving directly the product system under study (e.g. crude oil from the ground, or emissions to air)
- product flows: material or energy exchanged between the processes of the product system under study
- waste flows: material or energy leaving the product system

Each flow created must be defined by a reference flow property such as mass, volume, area, etc. It is also possible to define several flow properties for the same flow, but only one flow property must be selected as reference flow property.

#### 3.1 Create a new flow

- Create the flows *Granulates (PET, HDPE, PP)*; *Granulates (PET, HDPE, PP)*, transported; and *PET Bottle, filled* in the folder *A Water Bottle*
- Create the flows *Granulates (PC, LDPE, PB)*; *Granulates (PC, LDPE, PB)*, transported; and *PC Bottle, filled* in the folder *A Water Bottle*

To create a folder in the element folder *Flows*, right-click next to the elements folder *Flows*, select Add new child category and name it A Water Bottle. To create a new flow, right-click next to the folder A Water Bottle and select New flow. Name the new flow Granulates (PET, HDPE, PP), select the flow type product, choose the reference flow property Mass and click Finish.

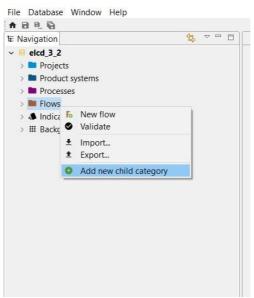


Figure 2: Create a new folder

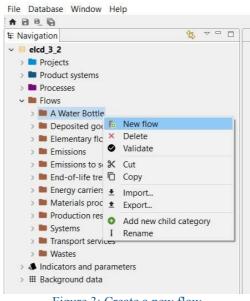


Figure 3: Create a new flow

New flow			
Creates a new flow			F
Name	Granulates (PET, HDPE,PP)		
Description			5
Flow type	Fe Product		
Reference flow property	邳 Mass		

Figure 4: Name, flow type and reference flow property of a new flow

The flow *Granulates (PET, HD, PP)* should now appear in the folder *A Water Bottle* in the Navigation windows as well as in the Editor window.

A B B, B			
🗉 Navigation 🗧 😇 🗖	Fe Granulates (PET, HD	PE,PP) 🛛	c
elcd_3_2 Projects	F.e General infor	mation: Granulates (PET, HDPE,PP)	C
<ul> <li>Product systems</li> <li>Processes</li> </ul>	- General informat	ion	
Flows A Water Bottle	Name	Granulates (PET, HDPE,PP)	
Fe Granulates (PET, HDPE,PP)  Deposited goods Elementary flows Elemissions	Description		^
> 🖿 Emissions to soil			~
> 🖿 End-of-life treatment	Version	00.00.000 🕤 🖹	
Energy carriers and technologies Materials production	UUID	45618cd5-ec7d-4356-b577-4eda87c6d123	
> Production residues in life cycle	Last change	2019-03-29T11:39:07+0100	
> 🖿 Systems	Infrastructure flow		
<ul> <li>Transport services</li> <li>Wastes</li> </ul>	Flow type	Fe Product	
<ul> <li>Indicators and parameters</li> <li>III Background data</li> </ul>		R <sub>b</sub> Create process	
	✓ Additional inform	nation	
	CAS number		
	Formula		
	Synonyms		
	Location		~
	General information F	ow properties	

Figure 5: New flow in the Navigation and Editor window

Now create more flows according to Table 1.

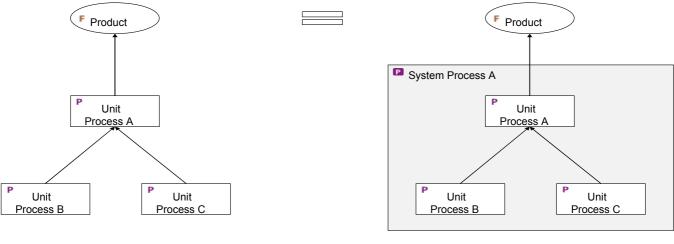
#### Table 1: Inputs for creating new flows

Flow name	Flow type	Reference flow property
Granulates (PET, HDPE, PP), transported	Product	Number of items
PET Bottle, filled	Product	Mass
Granulates (PC, LDPE, PB)	Product	Mass
Granulates (PC, LDPE, PB), transported	Product	Number of items
PC Bottle, filled	Product	Mass

#### 4 Processes

Processes are sets of interacting activities that transform inputs into outputs. Every process is defined by an output flow as a quantitative reference with the flow type product flow, which is either selected or created when creating a project. openLCA distinguishes two types of processes:

- Unit Processes: smallest unit analysed for which input and output data are quantified
- System Processes: unit for which input and output data are aggregated



Unit Process

System Process Figure 6: Unit and system processes

#### 4.1 Create a new process

- Create the processes *PET Granulate Production*, *PET Transport A*, and *PET Bottle Production* of the product system *PET Bottle Production*
- Create the processes *PC Granulate Production*, *PC Transport A*, and *PC Bottle Production* of the product system *PC Bottle Production*

To create a folder in the element folder Processes, right-click next to the elements folder *Processes*, select *Add new child category* and name it *A Water Bottle*. To create a new process, right-click next to the folder *A Water Bottle* and select *New process*. Name the new process *PET Granulate Production*, select the quantitative reference *Granulates (PET, HDPE, PP)* and click *Finish*.

Navigation		\$ ▽□□
<ul> <li>elcd_3_2</li> <li>Projects</li> <li>Product sy:</li> <li>Processes</li> </ul>	stems	
<ul> <li>Flows</li> <li>Indicators</li> </ul>	<ul><li>New process</li><li>Validate</li></ul>	
> 🎛 Backgrour	<ul><li>Import</li><li>Export</li></ul>	
	Add new child	category

Figure 7: Create a new folder

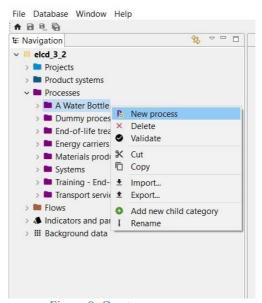


Figure 8: Create a new process

ca			^
New process			D
New process			
Name	PET Granulate Production		
	Create a waste treatment process		
	Create a new flow for the process		
Quantitative reference			
	🗸 🖿 A Water Bottle		1
	F. Granulates (PC, LDPE, PB)		
	Fe Granulates (PC, LDPE, PB), transported		
	Fe Granulates (PET, HDPE, PP), transported		
	Re Granulates (PET, HDPE, PP)		
	F. PC Bottle, filled		
	F.º PET Bottle, filled		
	> Deposited goods		
	s 🖿 End of life treatment		
		_	
	Finish	Can	cel

Figure 9: Name and quantitative reference of a new process

The process *PET Granulate Production* created should now appear in the folder *A Water Bottle* in the Navigation windows as well as open in the Editor Window.

🗉 Navigation 🛛 😤 🔻 🗆 🗖	P PET Granulate Production 🕸	
elcd_3_2 Projects	P General information: PET Granulate Production	C
	← General information	
P PET Granulate Production	Name PET Granulate Production	
<ul> <li>Dummy processes</li> <li>End-of-life treatment</li> <li>Energy carriers and technologies</li> <li>Materials production</li> </ul>	Description	< >
<ul> <li>Systems</li> <li>Training - End-of-life treatment</li> </ul>	Category A Water Bottle	
> Transport services	Version 00.00.000 (-) (-)	
> 🖿 Flows		
Indicators and parameters	UUID 2c015a83-198c-4afb-a939-b3a2242b8d09	
> III Background data	Last change 2019-03-29T12:09:43+0100	
	Infrastructure process	
	- Time	
	Start date 29.03.2019	
	End date 29.03.2019	
	Description	< >
	✓ Geography	

Figure 10: New Process in the Navigation and Editor window

The Process Editor window is structured in several tabs at the bottom of each Editor window. In the Input/Output tab you can see that the quantitative reference flow *Granulates (PET, HDPE, PP)* selected appears as the output flow for the process *PET Granulate Production*.

Add the input flows in the Inputs section of the Inputs/ Outputs tab as described in Table 2 by using the flow filter: Press the green + button on the top right corner, or double- click in the column Flow of the Inputs Section.

Table 2: Inputs for the processes of the product system *PET Bottle Production* 

Process	ntitative Input Flows rence	Amount
---------	-----------------------------	--------

PET Granulate Production	Granulates (PET, HDPE, PP)	polyethylene terephthalate (PET) granulate	60 g
		polyethylene high density granulate (PE-HD)	4 g
		polypropylene granulate (PP)	1 g
PET Transport A	Granulates (PET, HDPE, PP) transported	Granulates (PET, HDPE, PP)	0.065 kg
		Transport in t*km	0.065 kg*500 km
PET Bottle Filling	PET Bottle, filled	Granulates (PET, HDPE, PP), transported	1 item
		Drinking water	1 kg

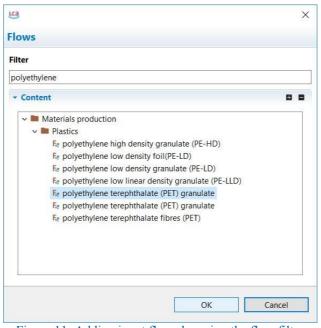


Figure 11: Adding input flows by using the flow filter

**Note!** When you search for flows by using the flow filter, only folders containing the keywords you have entered will be shown in the content section. The flow *polyethylene terephthalate (PET) granulate* appears twice because these flows are output flows of different production processes. Select the flow, which has the provider *Polyethylene terephthalate (PET) granulate, production mix, at plant, amorphous - RER.* In case of doubt add both flows and check their provider to select the right process.

It is also possible to use the search function at the top right corner to search any element within the active database. To search in different types of database elements use the arrow icon next to the search bar.

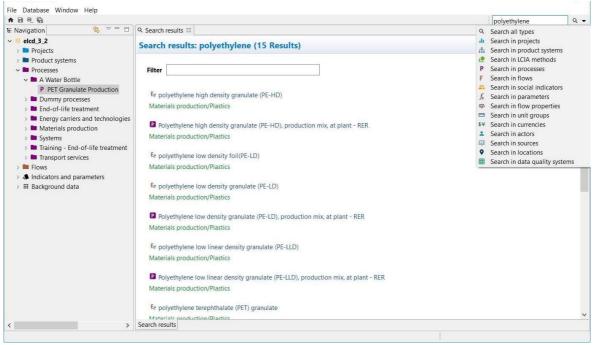


Figure 12: Search function

It is also possible to search the flows in the Navigator window and add them as inputs for the process by using drag and drop.

🗄 Navigation 😫 🗢 🗆	P *PET Granulate Production		+1		•
> Processes					-
✓ ■ Flows	P Inputs/Outputs: PET Granulate Proc	luction			
> A Water Bottle					
> Deposited goods	✓ Inputs			0	×
Elementary flows		Ingenie werden			_
Emissions	Flow	Category	Amount		
> Emissions to soil	Re polyethylene terephthalate (PET) granulate	Materials production/Plastics	1.00000 🛤	🕮 kg	
> End-of-life treatment					
> Energy carriers and technologies	Fe polyethylene high density granulate (PE-HD)				
Materials production					
> E Glass and ceramics					
> 🖿 Inorganic chemicals					
> 🖿 Metals and semimetals					
> 🖿 Organic chemicals	<				>
> 🖿 Other materials					
> 🖿 Other mineral materials	* Outputs			0	×
> E Paper and cardboards					
v 🖿 Plastics	Flow	Category	Amount	Unit	
Fe acrylonitrile-butadiene-styrene granulate (ABS)	Fe Granulates (PET, HDPE,PP)	A Water Bottle	1.00000	📼 kg	
Re high impact polystyrene granulate (HIPS)					
Fe nylon 6 glas filled (PA 6 GF)					
Fe nylon 6 granulate (PA 6)					
Fe nylon 66 GF 30 compound (PA 66 GF 30)					
Er nylon 66 granulate (PA 66)					
E <sub>2</sub> polyacrylonitrile fibres (PAN)					
Fe polyamide 6.6 fibres (PA 6.6)					
Fe polybutadiene granulate (PB)	<				>
Fe polycarbonate granulate (PC)					
Re polyethylene high density granulate (PE-HD)	<				>
<pre></pre>	General information Inputs/Outputs Administrative in	f Modeling and vali Decomptors Al	location Cocial areas	te Impact anal	weie

Figure 13: Adding input flows from the Navigation window by using drag and drop

Once you have found the flows you can adjust the amounts needed for each input and output flow according to Table 2. Double-click in the column Provider to connect the input flows with their respective upstream supply chain and save your changes.

Note! Number format: Use a decimal point instead of a decimal comma.

luction							
Category	Amount	Unit	C	Un	A	Provider	Data qu
Materials production/Plastics	0.00400	📼 kg		none		P Polyethylene high density granulate (PE-HD), production mix, at plant - RER	
Materials production/Plastics	0.06000	📖 kg		none		P Polyethylene terephthalate (PET) granulate, production mix, at plant, amorphous - RER	
Materials production/Plastics	0.00100	📟 kg		none		P Polypropylene granulate (PP), production mix, at plant - RER	
Category	Amount	Unit	С	Uncerta	ainty	Avoided product Provider Data quality entry Des	scriptio
A Water Bottle	0.06500	💷 kq		none			
	Category ^ Materials production/Plastics Materials production/Plastics Materials production/Plastics Category	Category Amount Category Amount Category Octoor Category Amount Category Amount Category Amount Category Amount	Category Amount Unit Materials production/Plastics 0.00400 = kg Materials production/Plastics 0.00600 = kg Materials production/Plastics 0.00100 = kg Category Amount Unit	Category Amount Unit C Materials production/Plastics 0.00400 = kg Materials production/Plastics 0.006000 = kg Materials production/Plastics 0.00100 = kg Category Amount Unit C	Category     Amount     Unit     C     Un       Materials production/Plastics     0.0400     Image: kg     none       Materials production/Plastics     0.00100     Image: kg     none       Materials production/Plastics     0.00100     Image: kg     none       Category     Amount     Unit     C     Uncertaint	Category     Amount     Unit     C     Un     A       Materials production/Plastics     0.00400     Image: kg     none       Materials production/Plastics     0.00100     Image: kg     none       Materials production/Plastics     0.00100     Image: kg     none       Category     Amount     Unit     C     Uncertainty	Category     Amount     Unit     C     Un     A     Provider       Materials production/Plastics     0.00400     Image: kg     none     P     Polyethylene high density granulate (PE-HD), production mix, at plant - RER       Materials production/Plastics     0.00100     Image: kg     none     P     Polyethylene terephthalate (PET) granulate, production mix, at plant, amorphous - RER       Materials production/Plastics     0.00100     Image: kg     none     P     Polypropylene granulate (PP), production mix, at plant - RER       Category     Amount     Unit     C     Uncertainty     Avoided product     Provider     Data quality entry     Detection

Figure 14: Inputs/Outputs tab of the process editor for the process PET Granulate Production

**Note!** Unsaved Changes in the Editor are indicated with an \*. Save your changes by clicking the Save button under the Main Menu or use command Ctrl + S.

Now create a second process *PET Transport A* with the quantitative reference *Granulates (PET, HDPE, PP), transported.* To connect the first process with the second process of the production chain, the output flow *Granulates (PET, HDPE, PP)* of the first process (*PET Granulate Production*) must be used as an input flow of the second process (*PET Transport A*). Add the respective amounts for each flow (table 2) and define the provider. Select the provider *Lorry transport, Euro 0, 1, 2, 3, 4 mix, 22 t total weight, 17,3t max payload - RER* for the input flow *transport in t\*km*.

Inputs									
Flow	Category	Amount	Unit	Uncertainty	Provid	ler			
F.e Granulates (PET, HDPE,PP)	A Water Bottle	0.06500	🚥 kg	none	P PET Granulate Production				
Fe transport in t*km	Transport services/Other transport	0.065*500	📼 kg*km	none	P Lorry transport, Euro 0, 1, 2, 3, 4 mix, 22 t total weight, 17,3t max payload				payload - I
<									
Outputs									
	Category	Amount	Unit	Costs/Reve	enues l	Uncertainty	Avoided product	Data quality entry	Descriptio

Figure 15: Inputs/Outputs tab of the process editor for the process PET Transport A

Create the third process PET Bottle Filling according to Table 2.

Inputs										
Flow	Category	Amount	Unit	Uncertainty	Provide	er				
Re Granulates (PET, HDPE, PP), transported	A Water Bottle	1.00000	💷 Item(s)	none	P PET	Transport A				
Fe drinking water	Materials production/Water	1.00000	📼 ka	none	P Drin	king water, pro	duction mix, at plant.	water purifica	tion treatment, from gro	undwater -
is drinking water	water as production, water	1.00000								
<	waterials production, water	1.00000								
	waterials production, water									
<	Category		nt Unit			Uncertainty	Avoided product	Provider	Data quality entry	Descripti

Figure 16: Inputs/Outputs tab of the process editor for the process PET Bottle Filling

When you have finished creating all processes of the product system *PET Bottle Production*, you create the processes of the product system *PC Bottle Production* according to **Table 3**.

Process	Quantitative Reference	Input Flows	Amount
PC Granulate	Granulates	polycarbonate granulate	60 g
Production	(PC, LDPE, PB)	(PC)	

Table 3: Inputs for the processes of the product system PC Bottle Production

		polyethylene low density granulate (PE- LD)	4 g
		polybutadiene granulate (PB)	1 g
PC Transport A Granulates (PC, LDPE, PB), transported		Granulates (PC, LDPE, PB)	0.065 kg
		Transport in t*km	00065 kg*500 km
PC Bottle Filling	PC Bottle, filled	Granulates (PC, LDPE, PB), transported	1 item
		Drinking water	1 kg

Inputs									
Flow	Category	Amount	Unit	Uncertainty	Provi	der			
Fe polycarbonate granulate (PC)	Materials production/Plastics	0.06000	📟 kg	none	P Polycarbonate granulate (PC), production mix, at plant - RER				
Repolyethylene low density granulate (PE-LD)	Materials production/Plastics	0.00400	📼 kg	none	P Polyethylene low density granulate (PE-LD), production mix, at plant - RE				
e polybutadiene granulate (PB)	Materials production/Plastics	0.00100	📼 kg	none	P Polybutadiene granulate (PB), production mix, at plant - RER				
(									
Dutputs									
Flow	Category	Amount	Unit	Costs/Rev	enues	Uncertainty	Avoided product	Provider	Data quality entr
	A Water Bottle	0.06500	Spacesz.			none			

Figure 17: Inputs/Outputs tab of the process editor for the process PC Granulate Production

Inputs	1.4	220	Factor	Desc 21	1222 858			
Flow	Category	Amount	Unit	Uncertainty	/ Provider			
Fe Granulates (PC, LDPE, PB)	A Water Bottle	0.06500	🚥 kg	none	P PC Granulate Production			
Re transport in t*km	Transport services/Other transport	0.065*500	📟 kg*km	none	P Lorry transport, Euro 0, 1, 2, 3, 4 mix, 22 t total weight, 17,3t max payload			
COutputs								

Figure 18: Inputs/Outputs tab of the process editor for the process PC Transport A

Inputs/Outputs: PC Bottle Filli - Inputs										
Flow	Category	Amount	Unit	Uncertainty	Provider					
Fe Granulates (PC, LDPE, PB), transported	A Water Bottle	1.00000	Item(s)	none	P PC Transport A					
Fe drinking water	Materials production/Water	1.00000	💷 kg	none	P Drinkin	g water, produ	ction mix, at plant, wa	ter purification	treatment, from ground	dwater - RF
< v Outputs										
Flow	Category	Amou	nt Unit	Cost	s/Revenues	Uncertainty	Avoided product	Provider	Data quality entry	Descrip
Fe PC Bottle, filled	A Water Bottle	1 0650	0 🚥 ka			none				

Figure 19: Inputs/Outputs tab of the process editor for the process PC Bottle Filling

### 5 Product systems

A product system contains all processes under study. The product system can consist of one process only or a network of multiple processes and is defined by the reference process.

In openLCA, the impacts can be calculated for a product system. The reference process of the product system is used to calculate the impacts for all connected upstream processes of the product system.

In openLCA, product systems can be created automatically or manually. For illustrative purposes, we will exemplary create a product system with automatic linking of processes and one with manual linking. However, if the ELCD or GaBi database is used, the product systems should always be created manually.

#### 5.1 Create a product system

- Create the product system PET Bottle Production with automatic linking of processes
- Create the product system PC Bottle Production with manual linking of processes

When you have finished creating all processes of the production chain you can create the product system based on the last process as the reference process of the product system.

Go to the *General Information* tab of the *PET Bottle Filling* process editor and press the button *Create product* system or use *Create product system* icon in the main menu.

File Database Window Help		+ [		
<ul> <li>▲ B. 9. % 10 10</li> <li>★ T D.</li> </ul>	P PET Bottle Filling 18			•
<pre>v = elcd_3_2 &gt; Projects</pre>	P General information: PET Bottle Filling		C	~
<ul> <li>Product systems</li> <li>Processes</li> <li>A Water Bottle</li> </ul>	General information			
P PC Bottle Filling	Name PET Bottle Filling			
P PC Granulate Production     P PC Transport A     P PET Bottle Filling     P PET Granulate Production     P DET Granulate Production	Description		< >	
P PET Transport A     Dummy processes     End-of-life treatment     Energy carriers and technologies     Materials production     Sestems	Category         A Water Bottle           Version         00.00,001 (*) (*)           UUID         553ec4bc-328f-45b3-b8de-1ec243f22f7b			
Training - End-of-life treatment     Transport services     Flows     M Indicators and parameters	Last change 2019-03-29T13:29:49+0100 Infrastructure process Create product system			
> III Background data				
< >>	Description General information Inputs/Outputs Administrative information Modeling and validation Parameters Allocation Soc	ial aspects Impact analysis	\$ \$	~

Figure 20: Create a product system in the process editor

Name the product system *PET Bottle Production*, select *PET Bottle Filling* as the reference process, select *Auto-link processes*, for provider linking select *only link default providers*, as preferred process type select *System process* and click *Finish*. In this way, all connections between the processes are established.

LCa			$\times$
New product sys	tem		•
Creates a new prod	luct system	ė	ėė
Name	PET Bottle Production		
Reference process			
	<ul> <li>P PET Bottle Filling</li> <li>P PET Bottle Usage (Material Flow Logic)</li> <li>P PET Bottle Usage (Opposite Direction Approach)</li> <li>P PET Granulate Production</li> <li>P PET Transport A</li> <li>&gt; Bottle - End-of-life treatment</li> <li>&gt; End-of-life treatment</li> <li>&gt; Energy carriers and technologies</li> <li>&gt; Materials production</li> <li>&gt; Sustems</li> <li>✓ Auto-link processes</li> <li>Check multi-provider links (experimental)</li> <li>Provider linking</li> <li>Ignore default providers</li> <li>Prefer default providers</li> <li>Only link default providers</li> <li>Unit process</li> <li>System process</li> </ul>		
	Cut-off		
	Finish	Cancel	

Figure 21: Create the product system *PET Bottle Production* 

The product system *PET Bottle Production* will open in the Editor window with the *General information* tab. Go to the *Model graph* tab to see the product system created.

If *Auto-link processes* is selected, the upstream processes for input flow will automatically be considered, indicated by a + in the top left corner of each process. Double click on the processes to maximise the view and see the input and output product flows, click on the + button to expand the view and see the providers for the input flows of the unit processes you have modelled.

File Database Window Help 🏚 🖻 🖳 🍓 🖾 🕼 💿		1	۹.
	the PET Bottle Production ⊠		
<ul> <li>Iteragaton</li> <li>Iteragaton</li> <li>Iteragaton</li> <li>Projects</li> <li>Product systems</li> <li>Processes</li> <li>Flows</li> <li>Indicators and parameters</li> <li>Iteragaton</li> <li>Background data</li> </ul>	PET Transport A  PET Bottle Filling  PET Bottle Filling		
< >	General information Parameters Model graph		

Figure 22: Model graph of the product system PET Bottle Production

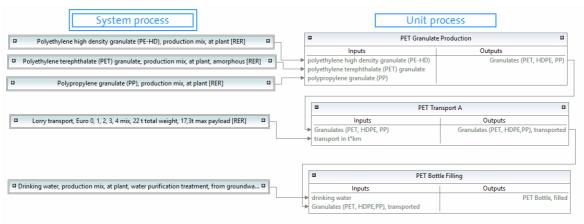


Figure 23: System and unit processes of the product system PET Bottle Production

**Note!** System processes in the model graph are framed with a double line, unit processes are framed with one line. Only product flows are shown as inputs and outputs for each process in the model graph, elementary flows are not shown.

To quantify the environmental impacts of the product system created, see section 7.1.

Create the second product system *PC Bottle Production* with the reference process *PC Bottle Filling*, but do not select *Auto-link processes*. The input flows of the process *PC Bottle Filling* are not connected to their respective providers and thus, the + at the top left of the process in the model graph is missing. To connect the input flows with their respective providers manually, select the process *PC Bottle Filling* by clicking on it, then right-click and select *Search providers for*. Click *Add* and *Connect* in the *Select Provider* window. Search, add and connect the providers for all input flows of each unit process created.

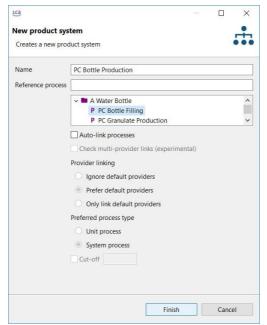


Figure 24: Create the product system PC Bottle Production

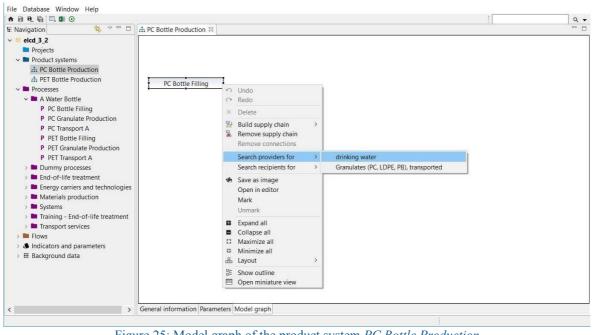


Figure 25: Model graph of the product system PC Bottle Production

Name	Add	Connect	Already present	Already connected	Is default provide
PC Transport A					0
<					>

Figure 26: Select providers of the product system PC Bottle Production

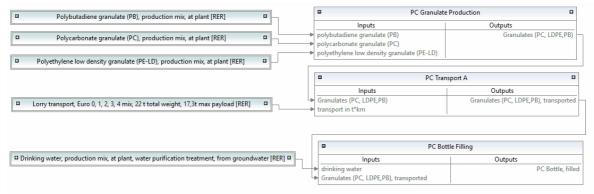


Figure 27: System and unit processes of the product system PC Bottle Production

**Note!** openLCA offers multiple ways to link providers. To find out if and how you should link the providers, click on Check linking properties in the menu item Database and you will see a recommendation for the database you are currently using. In this case, the *ELCD database* is used, which has processes without default providers as well as product flows with multiple providers. In Figure 24, the options *Ignore default providers* and *Prefer default providers* are ambiguous and the option *Only default providers* is incomplete. So, none of the provider linking options is recommended. Therefore, the checkmark *Auto-link processes* should not be activated when creating a product system and all providers should be set manually, as otherwise links that are not intended could also be set.

General database p	roperties				
#There are proce	sses in the dat	abase without default	providers for produ	ict inputs and/or was	te outputs (see t
#There are produ	ict and/or was	te flows in the databas	e that have multiple	e providers (see table	e below).
		Product flows with multiple providers	Ingnore default providers	Prefer default providers	Only default providers
Processes thout default	Yes	Yes	ambiguous	ambiguous	incomplete
providers		No			
	No	Yes			

Figure 28: Linking properties

#### 5.2 Cut-off

The use of cut-off reduces the required memory of openLCA and the calculation time. Unfortunately, this goes along with a loss of detail in the results.

• Build the product system PET Bottle Production (cut-off) with a cut-off 1E-1

Create a new product system and name it *PET Bottle Production (cut-off)*, select the reference process *PET Bottle Filling* activate *Cut-off* and enter the value 1e-01.

LCa	_			$\times$
New product sys	tem			•
Creates a new proc	luct system			
Name	PET Bottle Filling			
Reference process				
	P PET Bottle Filling   P PET Bottle Usage (Material Flow Logic)   P PET Bottle Usage (Opposite Direction Approach)   P PET Granulate Production   P PET Transport A   Bottle - End-of-life treatment   Dummy processes   End-of-life treatment   Energy carriers and technologies   Materials production   Auto-link processes   Check multi-provider links (experimental)   Provider linking   Ignore default providers   Only link default providers   Preferred process type   Unit process   System process   Cut-off			
	Finish		Cance	I
Figure 29: Cr	eate the product system PET Bottle Product	tion	(cut-o	эн <u>)</u>

Now open the model graph of the resulting product system and compare it with the product system *PET Bottle Production*. The *PET Bottle Production (cut-off)* has fewer upstream chains then *PET Bottle Production*.

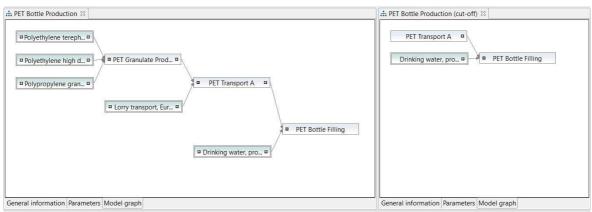


Figure 30: Model graph of the PET Bottle Production and the PET Bottle Production (cut-off)

#### 6 Projects

In openLCA, projects can be used to compare the impacts of different product systems.

#### 6.1 Create a project

• Create the project Water Bottle - PET vs PC Production

To create a new project, right-click the elements folder *Projects* and select *New Project* and name it *A Water Bottle - PET vs PC Production.* 

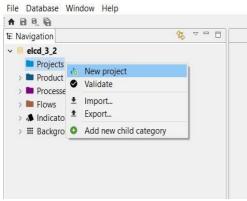


Figure 31: Create a new project

ca					×
New projec					
Creates a ne	w project				
Name	A Water Bottle	- PET vs PC Pr	oduction		
Description					^
					~
		Finish		Cano	el

Figure 32: Name of a new project

The Project Editor will open with the Project setup tab. To compare the environmental impacts of the product systems *PET Bottle Production* and *PC Bottle Production*, see section 7.2.

#### 7 Impact assessment

To quantify the environmental impacts of the product system analysed, the Impact Assessment methods must be imported into openLCA. A comprehensive package of environmental impact methods for use with all databases available in the Nexus web repository is provided free of charge by GreenDelta and can be downloaded from the openLCA website.

#### 7.1 Calculate a product system

• Calculate the environmental impacts of the product system *PET Bottle Production* using calculation type *Analysis* 

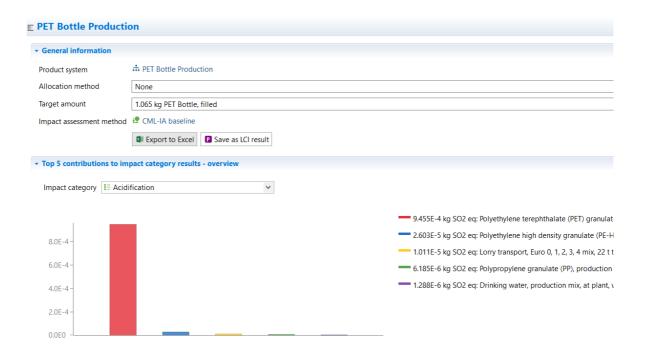
To calculate the environmental impacts of the product system analysed, go to the *General information* tab of the *PET Bottle Production* product system editor and press the button Calculate or use the calculate icon in the main menu. Select the Impact Assessment method *CML-IA baseline* and the calculation type *Analysis*.

File Database Window Help		4		Q .	•
🖩 Navigation 🔰 🌱 🗖	# PET Bottle Produ	iction 🛱			
✓ ⊜ elcd_3_2 > ■ Projects	. General int	formation: PET Bottle Production		C	^
<ul> <li>Product systems</li> <li>PC Bottle Production</li> </ul>	- General infor	mation			
PET Bottle Production     Processes	Name	PET Bottle Production			
Processes     Flows     Indicators and parameters     III Background data		irst created: 2019-03-29T14:50:27 inking approach during creation: Prefer default providers; Preferred process type: System process	^		
			~		
	Version 0	0.00.002 🕤 🛞			
	UUID	9dab5a4f-7113-4f82-a455-7d8b7552f71a			
		019-03-29T15:08:32+0100			
	Process	P PET Bottle Filling			
	Product	Fe PET Bottle, filled	~		
	Flow property	49 Mass	~		
	Unit	m kg	*		
	Target amount	1.065			~
< >>	General informatio	n Parameters Model graph			

Figure 33: Calculate a product system

Calculation properties	_		
Calculation properties			
Please select the properties for the	calculation		
	[		
Allocation method	None	¥	
Impact assessment method	😍 CML-IA baseline	~	
Normalization and weighting set		*	
Calculation type	○ Quick results	lo Simulation	
	Include cost calculation		
	Assess data quality		
	< Back Next > Finish	Cancel	

Figure 34: Calculation properties







Impact analysis: CML-IA baseline					
Subgroup by processes  Don't show < 1	<b>€</b> %				
Name	Category	Inventory result	Impact factor	Impact result	Unit
> IE Acidification				0.00099	kg SO
> IE Photochemical oxidation				6.40905E-5	kg C2.
IE Fresh water aquatic ecotox.				0.00027	kg 1,4.
IE Ozone layer depletion (ODP)				1.15288E-11	kg CF.
> IE Abiotic depletion				2.10139E-9	kg Sb.
IE Terrestrial ecotoxicity				4.97674E-5	kg 1,4
IE Abiotic depletion (fossil fuels)				0.00000	MJ
> IE Global warming (GWP100a)				0.21211	kg CO
III Marine aquatic ecotoxicity				16.03829	kg 1,4
> IE Eutrophication				6.51249E-5	kg PO
> IE Human toxicity				0.01590	

Figure 36: Impact analysis

#### 7.2 Calculate a project

• Compare the environmental impacts of the product systems *PET Bottle Production* and *PC Bottle Production* 

To calculate the environmental impacts of a project, go to the Project setup tab of the *A Water Bottle PET vs PC Production* project editor and enter the information required. Select the LCIA method *CML-IA baseline* and choose the impact categories Impact category *Global warming (GWP100a)* and *Human toxicity* in the LCIA methods section of the *Project setup* tab. Enter the product systems *PC Bottle Production* and *PET Bottle Production* by double-clicking in the product system column of the compared product system section and rename them PC and PET respectively. Once you have finished the project setup, save the changes and press the button Report or use the calculate icon in the main menu.

Acidification     Acidificat     Eutrophication     Eutrophication     Eutrophication     Eutrophication     Eutrophication     Eutrophication     Eutrophication     Eutrophication     Global warming (GWP100a)     Global w     Eutrophication     Global warming (GWP100a)     Global w     Eutrophication     Global warming (GWP100a)     Global w     Eutrophication     Global warming (GWP100a)     Global warming (GWP1					
Name       A Water Bottle -PET vs PC Production         Description	Production				
Name       A Water Bottle -PET vs PC Production         Description					
Description       Intel Deale Feither Frederiction         Wersion       00.00.006         UUID       699577ad-2939-4b19-8a7a-8167ca774fa3         Last change       2020-02-13T14:26:50+0100         in Report       Interport         LCIA Method       Impact category         LCIA Method       Impact category         Display       Label in r         Impact category       Display         Labiotic depletion       Abiotic d         Impact category       Display         Labiotic depletion (fossil fuels)       Abiotic d         Impact category       Display         Impact category       Global warming (GWP100a)         Impact category       Human toxicity         Impact category       Human toxicity         Impact product s					
Version 00.00.006 UUID 699577ad-2939-4b19-8a7a-8167ca774fa3 Last change 2020-02-13T14:26:50+0100 ILCIA Method LCIA Method LCIA Method LCIA Method ILCIA Method ILC					
Version       00.00.006         JUID       699577ad-2939-4b19-8a7a-8167ca774fa3         Last change       2020-02-13T14:26:50+0100         Image: and the second					
JUID       699577ad-2939-4b19-8a7a-8167ca774fa3         .ast change       2020-02-13T14:26:50+0100         Image: ast change       Compared product systems         Nome       Product system       Display         Labeline reget       Image: ast change         Image: ast change       Display       Alloca         Image: ast change       PC       PC Bottle Production       Image: Alloca					
JUID       699577ad-2939-4b19-8a7a-8167ca774fa3         .ast change       2020-02-13T14:26:50+0100         il Report       Interport         LCIA Method       Interport         LCIA Method       Interport         LCIA Method       Interport         Impact category       Display         Labiotic depletion       Abiotic depletion         Abiotic depletion       Abiotic depletion         Abiotic depletion       Acidification         Eutrophication       Eutrophic         Impact category       Global warming (GWP100a)         Global warming (GWP100a)       Global warming category         Maxine accutoric estensistion       Maxine accutoric estensistion         Compared product systems       Display       Alloca         Name       Product system       Display       Alloca					
JUID       699577ad-2939-4b19-8a7a-8167ca774fa3         .ast change       2020-02-13T14:26:50+0100         it       Report         LCIA Method       CML-1A baseline         Normalization and weighting set       Impact category         Display       Label in r         Abiotic depletion       Abiotic de         Abiotic depletion       Abiotic de         Eutrophication       Eutrophic         Eif Fresh water aquatic ecotox.       Fresh water         Global warming (GWP100a)       Global w         Human toxicity       Human toxicity         Maxine acception       Maxine acception         Maxine State       Maxine acception         Maxine State       Maxine acception         Bibbal warming (GWP100a)       Global w         Maxine State       Maxine acception         Maxine Compared product system       Display         PC       PC Bottle Production       Maxine State					
Loss Har Loss Har Core Core Core Loss Har Loss Har Core Core Core Loss Har Loss Har Core Core Loss Har Loss					
Il Report         LCIA Method         LCIA Method         LCIA Method         Inpact category         Display         Label in n         Abiotic depletion         Abiotic depletion (fossil fuels)         Abiotic depletion         Acidification         Eutrophication         Eutrophication         Global warming (GWP100a)         Human toxicity         Human toxicity         Marine so         Compared product systems         Name       Product system         PC					
Il Report         LCIA Method         LCIA Method         Impact Category         Display         Label in n         Abiotic depletion         Acidification         Eutrophication         Eutrophication         Elefobal warming (GWP100a)         Global warming (GWP100a)         Human toxicity         Human toxicity         Human toxicity         Compared product systems         Name       Product system         PC not PC Bottle Production					
LCIA Method         LCIA Method         Normalization and weighting set         Impact category       Display         Label in r         Abiotic depletion       Abiotic deletion         Abiotic depletion (fossil fuels)       Abiotic deletion         Abiotic depletion       Eutrophic         Eutrophication       Eutrophic         Fresh water aquatic ecotox.       Fresh water         Global warming (GWP100a)       Global w         Human toxicity       Human toxicity         Human toxicity       Maxing set         Compared product systems       Display         Name       Product system       Display         PC       PC Bottle Production       V					
LCIA Method Normalization and weighting set Impact category Display Label in r Abiotic depletion Abiot					
LCIA Method Normalization and weighting set Impact category Display Label in r Abiotic depletion Abiot					
LCIA Method Normalization and weighting set Impact category Display Label in r Abiotic depletion Abiotic Acidification Eutrophi Fresh water aquatic ecotox. Fresh water aquatic ecotox. Global warming (GWP100a) Global w Human toxicity Human toxicity Human toxicity Abiotic centexistic Abiotic centexistic Compared product systems PC cit PC Bottle Production None					
Normalization and weighting set         Impact category       Display         Label in r         Abiotic depletion       Abiotic diffication         Abiotic depletion (fossil fuels)       Abiotic diffication         Eutrophication       Eutrophi         Fresh water aquatic ecotox.       Fresh water aquatic ecotox.         Global warning (GWP100a)       Global w         Human toxicity       Human toxicity         Maxing source contensities       Maxing source contensities         Compared product systems       Display       Alloca         Name       Product system       Display       Alloca         PC       PC Bottle Production       Image: Point and the production       None					
Normalization and weighting set         Impact category       Display         Label in r         Abiotic depletion         Abiotic depletion (fossil fuels)         Abiotic depletion (fossil fuels)         Abiotic depletion         Eutrophication         Eutrophication         Eutrophication         Eutrophication         Eutrophication         Eutrophication         Human toxicity         Human toxicity         Human toxicity         Compared product systems         Name       Product system         PC       PC Bottle Production					
Impact category     Display     Label in r       Impact category     Display     Abiotic depletion (fossil fuels)     Abiotic depletion (fossil fuels)       Impact category     Display     Abiotic depletion (fossil fuels)     Abiotic depletion (fossil fuels)       Impact category     Display     Acidification     Acidification       Impact category     Impact category     Display     Allocation       Impact category     Impact category     Impact category     None       Policity     Product system     Display     Allocation	2				
Abiotic depletion       Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)         Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)         Acidification       Acidification       Acidification         Eutrophication       Eutrophic         Fresh water aquatic ecotox.       Fresh water aquatic ecotox.         Global warming (GWP100a)       Global w         Human toxicity       Human toxicity         Marine anuatic ecotoxitity       Marine and toxicity         Compared product systems       Display         Name       Product system       Display         PC       PC Bottle Production       None					
Abiotic depletion       Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)         Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)         Acidification       Acidification       Acidification         Eutrophication       Eutrophic         Fresh water aquatic ecotox.       Fresh water aquatic ecotox.         Fresh water aquatic ecotox.       Fresh water aquatic ecotox.         Global warming (GWP100a)       Global warming         Human toxicity       Human toxicity         Marine source contactive       Marine source contactive         Compared product systems       Display         Name       Product system       Display         PC       PC Bottle Production       None					
Abiotic depletion       Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)         Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)         Acidification       Acidification       Acidification         Eutrophication       Eutrophic         Fresh water aquatic ecotox.       Fresh water aquatic ecotox.         Fresh water aquatic ecotox.       Fresh water aquatic ecotox.         Global warming (GWP100a)       Global warming         Human toxicity       Human toxicity         Marine source contactive       Marine source contactive         Compared product systems       Display         Name       Product system       Display         PC       PC Bottle Production       None	report	D			
Image: Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)       Abiotic depletion (fossil fuels)         Image: Acidification       Acidification       Acidification         Image: Acidification       Eutrophication       Eutrophication         Image: Fresh water aquatic ecotox.       Fresh water aquatic ecotox.       Fresh water aquatic ecotox.         Image: Global warming (GWP100a)       Image: Global warming (GWP100a)       Image: Global warming (GWP100a)         Image: Global warming (GWP100a)       Image: Global warming (GWP100a)       Image: Global warming (GWP100a)         Image: Global warming (GWP100a)       Image: Global warming (GWP100a)       Image: Global warming (GWP100a)         Image: Global warming (GWP100a)       Image: Global warming (GWP100a)       Image: Global warming (GWP100a)         Image: Global warming (GWP100a)       Image: Global warming (GWP100a)       Image: Global warming (GWP100a)         Image: Global warming (GWP100a)       Image: Global warming (GWP100a)       Image: Global warming (GWP100a)         Image: Global warming (GWP100a)       Image: Global warming (GWP100a)       Image: Global warming (GWP100a)         Compared product systems       Image: Global warming (GWP10a)       Image: Global warming (GWP10a)         Name       Product system       Image: Global warming (GWP10a)       Image: Global warming (GWP10a)         Name       Product sy					
Image: Acidification       Acidification         Image: Eutrophication       Eutrophication         Image: Fresh water aquatic ecotox.       Fresh water aquatic ecotox.         Image: Global warming (GWP100a)       Image: Global warming (GWP100a)         Compared product system       Marine same same same same same same same sam	lepletion (fossil fuels)				
I = Fresh water aquatic ecotox.       □       Fresh water         I = Global warming (GWP100a)       ☑       Global w         I = Human toxicity       ☑       Human toxicity         I = Marine source contactivity       ☑       Human toxicity         Compared product systems       Marine source         Name       Product system       Display         PC       IPC Bottle Production       ☑					
Image: Global warming (GWP100a)       Image: Global warming (GWP100a)         Image: Human toxicity       Image: Global warming (GWP100a)         Image: Global warming (GWP100a)       Imag	cation				
Image: Global warming (GWP100a)     Image: Global warming (GWP100a)       Image: Human toxicity     Image: Global warming (GWP100a)       Image: Global warming (GWP100a)     Image: Global warming (GWP100a) <t< td=""><th>ter aquatic ecotox.</th><td></td><td></td><th></th><td></td></t<>	ter aquatic ecotox.				
Image: Human toxicity     Image: Human toxicity       Image: Human toxicity     Image: Human toxicity <t< td=""><th>arming (GWP100a)</th><td></td><td></td><th></th><td></td></t<>	arming (GWP100a)				
Compared product systems           Name         Product system         Display         Alloca           PC         Image: Product system         Image: Product system         None					
Name Product system Display Alloca PC 📅 PC Bottle Production 🗹 None	austic acatovicity				
Name Product system Display Alloca PC 📅 PC Bottle Production 🗹 None					
Name Product system Display Alloca PC 📅 PC Bottle Production 🗹 None					
PC 👬 PC Bottle Production 🗵 None					
PC 🚓 PC Bottle Production 🗵 None	tion method Flow	Amo	ount Unit	Description	
	E. PC	Bottle, filled 1.065	5 📼 kg	-	
		T Bottle, filled 1.065			
	107 1		Ky		

Figure 37: Project setup

### Relative Results

The following chart shows the relative indicator results of the respective project variants. For each indicator, the maximum result is set to 100% and the results of the other variants are displayed in relation to this result.

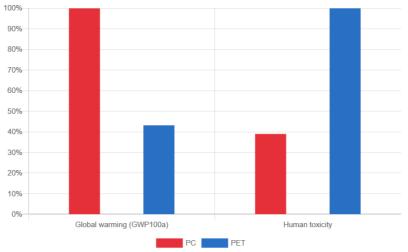


Figure 38: Relative results of the compared product system for the selected impact categories

#### 8 Parameters

In openLCA, parameters can be used on the process, Impact assessment method, product system, project and database level. Parameters can be used instead of concrete values for inputs/outputs. Modelling with parameters is useful for sensitivity analyses, i.e. if you want to investigate the effects of an aspect, or if data must be changed later in the process. Using parameters to enter calculation rules instead of concrete values also gives you more flexibility.

Global parameters are valid on all levels. Local parameters are parameters that are only valid for the process in which they are saved. In openLCA, all created parameters can be viewed under Window - Parameters.

#### 8.1 Global parameters

• Create a global parameter *PET\_granulate* and assign it the value 0.065

To create a global parameter, right-click the folder *Global parameters* in the folder *Indicators and parameters* and select *New parameter*. Name it *PET\_granulate*, choose the type Input parameter, assign the value 0.065 and click *Finish*.

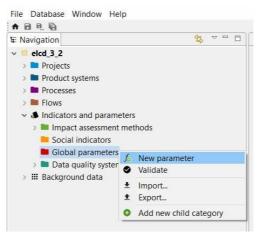


Figure 39: Create a new global parameter

New param	leter f.
Creates a ne	w parameter $J \chi$
Name	PET_granulate
Description	^
	~
Туре	Input parameter      Dependent parameter
Amount	0.065

Figure 40: Name and amount of a new parameter

Replace the PET values in the entire value chain of your PET bottle production with the parameter, i.e. change the amount of the flow *Granulates (PET, HDPE, PP)* in the process *PET Granulate Production* to *PET\_granulate*.

Data
norphous - RER

Figure 41: Inputs/Outputs tab of the process PET Granulate Production

#### 8.2 Local parameters

• Create a local parameter *distance\_A* and assign it the value 500

Open the *Parameters* tab of the process *PET Transport A* and click into the Input parameters area. Click *Create new*, name the parameter *distance\_A* and assign it the value 500. Next, open the Inputs/Outputs tab of the process *PET Transport A* and replace the distance with the new parameter. Click on the *1.23* symbol in the upper right corner to change the formula view.

A 🖯 🔍 🖓 📩 🕼					۹.
🖩 Navigation 🛛 😽 🔻 🗖	P PET Transport A 🛛				- E
<ul> <li>elcd_3_2</li> <li>Projects</li> </ul>	p Parameters: P	ET Transport A			
<ul> <li>Product systems</li> <li>Processes</li> </ul>	Global parameter	5			
<ul> <li>A Water Bottle</li> <li>P PC Bottle Filling</li> </ul>	+ Input parameters				
<ul> <li>P C Granulate Production</li> <li>P C Transport A</li> </ul>	Name			Value	Uncertainty
P PET Bottle Filling     P PET Granulate Production     P PET Granulate Production     P PET Transport A     Dummy processes     End-of-life treatment     Energy carriers and technologie     Materials production     Systems		Create new  Remove selected  Copy Paste Usage  Usage			
Training - End-of-life treatment	<ul> <li>Dependent paran</li> </ul>	neters			
<ul> <li>Transport services</li> <li>Flows</li> <li>Indicators and parameters</li> <li>Impact assessment methods</li> </ul>	Name		Formula		
<ul> <li>Social indicators</li> <li>Clobal parameters</li> <li>∫<sub>t</sub> PET_granulate</li> <li>Data quality systems</li> <li>Ⅲ Background data</li> </ul>	<				

Figure 42: Create a new local parameter

C

#### P Parameters: PET Transport A

lame	Value	Uncertainty	Description	
ET_granulate	0.065	none		

Name	Value	Uncertainty	Description
distance_A	500.0	none	

Figure 43: Parameters tab

Inputs								0 ×
Flow Fe Granulates (PET, HDPE,PP)	Category A Water Bottle	Amount Unit PET_granulate 📼 kg	Costs/Revenu	Uncertainty none	Avoided waste	Provider P PET Granu	Data quality	Descri
Fe transport in t*km	Transport services/Other tra	PET_granulate*distance_A 📟 kg*km		none		P Lorry trans		

Figure 44: Inputs/Outputs tab of the process PET Transport A

To investigate how different values for the parameter influence the results of the product system, create a new project *PET Parameter comparison*. Add the product system *PET Bottle Production* twice and name them *short distance* and *long distance*. Double-click into the Parameters area or use the + symbol to add the parameter *distance\_A*. Next, assign the value 50 to the parameter in the column short distance and 5000 in the column long distance. To calculate the results, choose an LCIA method and click Report.

earch parameters	
ilter	
- Parameters	
$f_x$ PET_granulate	
<ul> <li>Mathematical Science (v4.4, January 2015)</li> <li>P PET Transport A</li> </ul>	
$f_x$ distance_A	
ОК	Cancel

Figure 45: Add parameters to a project

Navigation		M				2	
Navigation 🛛 🖏 🗸 🗖 🗍	di PET Parameter compa	irison &					
v Projects	- Compared product	t systems					
<ul> <li>It PET Parameter comparison</li> <li>Product systems</li> </ul>	Name	Product system	Display	Allocation method	Flow	Amount	Unit
> Processes	short distance	# PET Bottle Production		None	Fe PET Bottle, filled	1.065	📖 kg
> Elows	long distance	# PET Bottle Production	<b>V</b>	None	F. PET Bottle, filled	1.065	📼 kg
<ul> <li>Indicators and parameters</li> <li>III Background data</li> </ul>							
	Parameters     Parameter	Context	Label in rep	ort Description	short distan		distance.
	Parameter P distance A	PET Transport A	distance A	Description	50.0	ce long 5000.	distance
	r ustaite_A	PET Hansport A	distance_A		30.0	3000.	
	- Process contributio	ons					-
	Brocorr						
	Process			Label in report			Description

Figure 46: Project PET Parameter comparison

### 9 End-of-life modelling

End-of-Life can be modelled following the natural direction of the material flow by using waste flows. This procedure is called Material Flow Logic. But not all databases support waste flows, e.g. ecoinvent. In this case, the Opposite Direction Approach, which is following the opposite direction of the material flow, can be used. In openLCA both ways of modelling waste are possible.

#### 9.1 Material flow logic

In the Material Flow Logic, the waste treatment process (*Waste incineration of plastics*) is modelled using a waste flow in the input table with a positive value. The waste generation process (*PET Bottle Usage*) is modelled using a waste flow in the output table with a positive value.

• Create the process *PET Bottle Usage (Material Flow Logic)* with the waste flow *waste incineration of plastics (PET, PMMA, PC)* as an output

In this tutorial, the processes *Waste incineration of plastics (Material Flow Logic)* and *Waste incineration of plastics (Opposite Direction Approach)* are used. Since the processes are not part of the database you are working on, you need to download them <u>here</u>. After, you have imported the file, you should find the respective processes in the folder *Bottle - End-of-life treatment*.



Open the process *Waste incineration of plastics (Material Flow Logic)*. The quantitative reference of the process is the *waste flow waste incineration of plastics (PET, PMMA, PC)* with a positive value, which you can find in the inputs table.

Inputs				0 >	K 1
Flow	Category	Amount	Unit	Costs/Revenues	^
Fe Uranium	Resource/in ground	95.54569	m MJ		
F.º Uranium depleted	Deposited goods/Radioactive waste	-0.00013	📖 kg		
& waste incineration of plastics (PET, PMMA, PC)	Deposited goods/End-of-Life (EoL) modelling	1000.00000	🚥 kg	96.00000 EUR	
F. Waste radioactive	Deposited goods/Radioactive waste	-0.00011	🚥 kg		-
Fe Water	Resource/in water	2399.14016	🚥 kg		ľ
FeWater ground	Resource/in water	21 90019	m ka		1
Outputs				0 >	x
Flow	Category	Amount	Unit	Costs/Revenues	1
Fe Acenaphthene	Emission to water/fresh water	1.01665E-9	🚥 kg		1
Fe Acenaphthene	Emission to water/ocean	3.34955E-8	🚥 kg		
Fe Acenaphthylene	Emission to water/fresh water	4.15797E-10	🚥 kg		
Fe Acenaphthylene	Emission to water/ocean	1.27321E-8	🚥 kg		
Fø Acetaldehyde	Emission to air/unspecified	2.01452E-5	🚥 kg		
Fe Acetic acid	Emission to air/unspecified	8.62282E-5	min ka		Y

Figure 48: Inputs/Outputs tab of the process *Waste incineration of plastics (Material Flow Logic)* 

Create a new process, name it *PET Bottle Usage (Material Flow Logic)*, for the quantitative reference select *Create a new flow* for the process, name it *PET Bottle, disposed* and select the flow property *Mass*. Open the Inputs/Outputs tab of the process, add the flow *PET Bottle*, filled to the input table and drag and drop the process *Waste incineration of plastics (Material Flow Logic)* into the outputs table. The waste flow *waste incineration of* 

*plastics (PET, PMMA, PC)* should now be the output with a positive value. Make sure that you enter the correct values in the Amount column. Next, create a new product system *PET Bottle Production (Material Flow Logic)* with the reference process *PET Bottle Usage (Material Flow Logic)*.

New process		D
New process		r
Name	PET Bottle Usage (Material Flow Logic)	
	Create a waste treatment process	
	Create a new flow for the process	
Quantitative reference	PET Bottle, disposed	
Reference flow property	책 Mass	~
	Finish Car	icel

Figure 49: Create a new process PET Bottle Usage (Material Flow Logic)

T Bottle Usage (Material Flow Log	gic) 🛛								
nputs/Outputs: PET Bot	tle Usage (Material F	low Logic	)						
Inputs									0
Flow	Category	Amount	Unit	Costs/Rev	Uncertainty	Avoided	Provider	Data quali	Descripti
Fe PET Bottle, filled	A Water Bottle	1.06500	🚥 kg		none		P PET Bo		
Outputs									0
Flow	Category	Amount	Unit	Costs/Rev	Uncertainty	Avoided p	Provider	Data quali	Descripti
Fe PET Bottle, disposed	A Water Bottle	0.06500	🚥 kg		none				
For waste incineration of plastics	Deposited goods/End	0.06500	🚥 ka		none		P Waste i		

Figure 50: Inputs/Outputs tab of the process PET Bottle Usage (Material Flow Logic)

#### 9.2 Opposite direction approach

In the Opposite Direction Approach, the waste treatment process (*Waste incineration of plastics*) is modelled using a product flow in the output table with a negative value (logically an input). The waste generation process (*PET Bottle Usage*) is modelled using a product flow in the input table with a negative value (logically an output).

• Create the process *PET Bottle Usage (Opposite Direction Approach)* with the product flow *waste incineration of plastics (PET, PMMA, PC)* as an input

Open the process *Waste incineration of plastics (Opposite Direction Approach)*. The quantitative reference of the process is the product flow *waste incineration of plastics (PET, PMMA, PC)* with a negative value, which you can find in the outputs table.

Inputs				0 >	< 1
Flow	Category	Amount	Unit	Costs/Revenues	^
Fe Aggregate, natural	Resource/in ground	0.12579	📟 kg		
Fe Air	Resource/in air	1.34460E4	📟 kg		
Fe Barite	Resource/in ground	1.01705E-12	📟 kg		
Fe Barite	Resource/in ground	0.03524	📟 kg		
Basalt, in ground	Resource/in ground	0.00737	📟 kg		
Fe Rauvite	Resource/in around	9 92536F-5	m ka		1
Outputs				0 >	<
Flow	Category	Amount	Unit	Costs/Revenues	^
FeVOC, volatile organic compounds, unspecified origin	Emission to water/fresh water	4.92955E-7	📟 kg		
FaVOC, volatile organic compounds, unspecified origin	Emission to water/ocean	2.64949E-8	📟 kg		
Fe waste incineration of plastics (PET, PMMA, PC)	End-of-life treatment/Energy recycling	-1000.00000	🚥 kg	96.00000 EUR	
Fe Water vapour	Emission to air/unspecified	42.74772	🚥 kg		
Fa Xenon-131m	Emission to air/unspecified	0.00612	🚥 kBq		-
Fa Xenon-133	Emission to air/unspecified	1 00129	IN VRA		Y

Figure 51: Inputs/Outputs tab of the process *Waste incineration of plastics (Opposite Direction Approach)* 

Create a new process, name it *PET Bottle Usage (Opposite Direction Approach)* and select the *flow PET Bottle, disposed* as the quantitative reference. Open the Inputs/Outputs tab of the process, add the flow *PET Bottle, filled* to the input table and drag and drop the process *Waste incineration of plastics (Opposite Direction Approach)* into the inputs table. The product flow *waste incineration of plastics (PET, PMMA, PC)* should now be an input with a negative value. Make sure that you enter the correct values in the *Amount* column. Next, create a new product system *PET Bottle Production (Opposite Direction Approach)* with the reference process *PET Bottle Usage (Opposite Direction Approach)*.

lew process								
New process								
Name	PET Bottle Usage (Opposite Direction Approach)							
	Create a waste treatment process							
	Create a new flow for the process							
Quantitative reference	PET Bottle, disposed							
	🗸 🖿 A Water Bottle							
	F.e PET Bottle, disposed							

Figure 52: Create a new process *PET Bottle Usage (Opposite Direction Approach)* 

nputs/Outputs: PET Bot	tle Usage (Opposite	Direction	Approad	h)					
				,					
Inputs									• •
Flow	Category	Amount	Unit	Costs/Rev	Uncertainty	Avoided	Provider	Data quali	Descripti
Fe PET Bottle, filled	A Water Bottle	1.06500	🚥 kg		none		P PET Bo		
Fe waste incineration of plastics	End-of-life treatment/	-0.06500	🚥 kg		none		P Waste i		
Outputs									•
Flow	Category	Amount	Unit	Costs/Rev	Uncertainty	Avoided p	Provider	Data quali	Descripti
Fe PET Bottle, disposed	A Water Bottle	0.06500	🚥 kg		none				

Figure 53: Inputs/Outputs tab of the process PET Bottle Usage (Opposite Direction Approach)

Finally, open and compare the model graphs of the product *systems PET Bottle Production (Material Flow Logic)* and *PET Bottle Production (Opposite Direction Approach)*. The Opposite Direction Approach is

following the opposite direction of the material flow. But if you calculate the product systems and compare the resulting impact analysis, they should be the same.

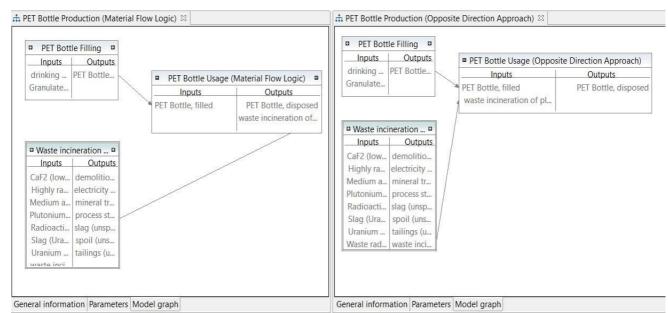


Figure 54: Model graphs of the product systems *PET Bottle Production (Material Flow Logic)* and *PET Bottle Production (Opposite Direction Approach)* 

Impact analysis: CML-IA baselin	e					Impact analysis: CML-IA baseline						
Subgroup by processes 🔽 Don	_	1 🗘 %				Subgroup by processes 🖌 Don't s	how < 1	* %				
Name	Category	Invento	Impa	Impact result	Unit	Name	Category	Inventory result	Impact factor	Impact result	Unit	
IE Abiotic depletion				2.23381E-9	kg Sb eq	IE Abiotic depletion				2.23381E-9	kg Sb eq	
> IE Abiotic depletion (fossil fue	e			0.00000	MJ	> IE Abiotic depletion (fossil fuels)				0.00000	MJ	
IE Acidification				0.00100	kg SO2 eq	> IE Acidification				0.00100	kg SO2 eq	
IE Eutrophication				6.76125E-5	kg PO4 eq	> IE Eutrophication				6.76125E-5	kg PO4 eq	
IE Fresh water aquatic ecotox.				0.00027	kg 1,4-DB eq	> I≣ Fresh water aquatic ecotox.				0.00027	kg 1,4-DB eq	
I = Global warming (GWP100a)	)			0.36967	kg CO2 eq	> IE Global warming (GWP100a)				0.36967	kg CO2 eq	
I≣ Human toxicity				0.01599	kg 1,4-DB eq	> IE Human toxicity				0.01599	kg 1,4-DB eq	
> IE Marine aquatic ecotoxicity				16.30189	kg 1,4-DB eq	> IE Marine aquatic ecotoxicity				16.30189	kg 1,4-DB eq	
> IE Ozone layer depletion (OD	p			1.88964E-10	kg CFC-11 eq	> I≡ Ozone layer depletion (ODP)				1.88964E-10	kg CFC-11 eq	
> IE Photochemical oxidation				6.50720E-5	kg C2H4 eq	> I≡ Photochemical oxidation				6.50720E-5	kg C2H4 eq	
> IE Terrestrial ecotoxicity				5.03566E-5	kg 1,4-DB eq	> IE Terrestrial ecotoxicity				5.03566E-5	kg 1,4-DB eq	

Figure 55: Impact analysis of the product systems *PET Bottle Production (Material Flow Logic)* and *PET Bottle Production (Opposite Direction Approach)* 

#### 10 Allocation

Often, there are multi-output processes, e.g. production of milk, leather and meat from a cow or the cogeneration of heat and power. There are two strategies to deal with it: system expansion and allocation. If an allocation is used, elementary flows and products from multi-output processes are mathematically divided into multiple processes. In openLCA, there are allocation methods for physical, causal and economic allocation.

• Create the project *PET Allocation comparison* and compare the calculated results if applying an allocation method in the process *Waste incineration of plastics (Material Flow Logic)* 

The process *Waste incineration of plastics (Material Flow Logic)* has the products electricity, process steam and waste incineration itself. In the tab *Allocation*, the default method for allocation between these three products can be selected and the different allocation factors can be seen. By clicking on *Calculate default values* the physical and the economic allocation factors will be added automatically if the columns *Amount* and *Cost/Revenues* in the output table have been set. In our case, only the factors for the economic allocation will be added, because the physical allocation factors cannot be calculated as the flows have different units. The causal allocation factors can be added by clicking into the fields in the Causal allocation area.

efault method Ecc	onomic		~						
۲	Calculate del	fault values							
Physical & econom	ic allocation								
Product				Physical		Economic			_
Re electricity from w	aste incinera	tion (3.12E3 MJ)		0.0	0.20957978	461321883			
Fe process steam fro	om waste inci	neration (1.01E4 MJ)		0.0	0.45255859	787428737			
F <sub>2</sub> waste incineratio	n of plastics (	(PET, PMMA, PC) (1.00E3 kg)		0.0	0.33786161	751249383			
Causal allocation									
Flow	Direction	Category	Amount	electricity from	n waste inciner	process steam	from waste inci	waste incineration of p	
Fe Acenaphthene	Output	Emission to water/fresh water	1.01665E-9 kg		0.0		0.0	0.0	
Fa Acenaphthene	Output	Emission to water/ocean	3.34955E-8 kg		0.0		0.0	0.0	
Fe Acenaphthylene	Output	Emission to water/fresh water	4.15797E-10 kg		0.0		0.0	0.0	
Fe Acenaphthylene	Output	Emission to water/ocean	1.27321E-8 kg		0.0		0.0	0.0	
Fe Acetaldehyde	Output	Emission to air/unspecified	2.01452E-5 kg		0.0		0.0	0.0	
Fe Acetic acid	Output	Emission to air/unspecified	8.62282E-5 kg		0.0		0.0	0.0	
	Output	Emission to water/fresh water	6.03947E-6 kg		0.0		0.0	0.0	1.16

General information Inputs/Outputs Administrative information Modeling and validation Parameters Allocation Social aspects Impact analysis Figure 56: Allocation tab of the process *Waste incineration of plastics (Material Flow Logic)* 

Next, create a new project *PET Allocation comparison*. In the project setup select an LCIA method, add the product system *PET Bottle Production (Material Flow Logic)* twice, select the *Economic allocation* method for the first product system, select *None* for the second and name it according to the allocation method. Click *Report* to see the results calculated using the different allocation methods. If no allocation method is selected, 100 per cent of the environmental impacts are assigned to the quantitative reference, otherwise, the environmental impacts are distributed among the products according to the allocation factors.

	omparison 없								
Project set	up: PET Alloca	tion co	omparison						
General info	ormation								
Name	PET Allocation com	parison							
Description									
Version	00.00.003								
UUID	40cc48fa-5533-4a74	-9117-c9e	eeedf857a6						
Last change	2020-02-13T14:38:55+	-0100							
	II Report								
LCIA Metho	d	🛃 CM	IL-IA baseline						
Normalizati	on and weighting set								
	sh ana weighting see								
Impact categ	jory	Display	Label in report	Descript	ion				
E Abiotic d	epletion		Abiotic depletion						
	epletion (fossil fuels)		Abiotic depletion (fossil fuels)						
E Acidificat			Acidification						
Eutrophic			Eutrophication						
			Fresh water aquatic ecotox.						
	2.5	¥	Global warming (GWP100a)						
🗄 Human te			Human toxicity						
III Marine av	untic acatovicity		Marino aquatic acatovicity						
Compared p	roduct systems								
Compared p	roduct systems								
Name	Product	t system		Display	Allocation method	Flow	Amount	Unit	Descript
Economi	Allocation 📩 PET	Bottle Pro	oduction (Material Flow Logic)		Economic	F. PET Bottle, disposed	0.065	📖 kg	
No Alloca					None	F. PET Bottle, disposed	0.065	💷 kg	
1									

Figure 57: Project setup of the project PET Allocation comparison

#### **Relative Results**

The following chart shows the relative indicator results of the respective project variants. For each indicator, the maximum result is set to 100% and the results of the other variants are displayed in relation to this result.

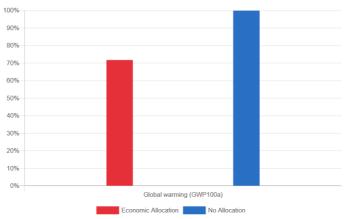


Figure 58: Relative results of the project PET Allocation comparison

# 11 Additional information

#### 11.1 Basic command

Table 4: Basic commands in openLCA					
Command	Description				
Open element	Double click on the element or right-click on the element and select <i>open</i>				
Copy and paste	Right-click on the element to be duplicated and select <i>copy</i> , right-click on the folder or the Input/Output table, in which the copied element should be saved, and select <i>paste</i>				
Drag and Drop	Adding flows from the navigation window to the Input/ Output tab in the process editor or adding processes from the navigation window to the model graph in the product system editor				
Filter	Use the filter function for adding new flows to a process or for selecting the reference process in a product system				
Minimise/maximise element	Use the symbols				
Save element	Strg + S or use saving symbol in the main menu				
Save image	Right-click in the Editor window and select Save image				
Search	Use the search function to search any element within the active database				
Restore Windows	Go to <i>Windows</i> in the main menu and select <i>Show views</i> and <i>Other</i> or use restore symbol				
Number formats	Use a point for floating-point numbers, a comma is not accepted				

#### 11.2 Tips and tricks

**Copy and Paste compatibility within openLCA and with other software:** openLCA-users can seamlessly copy and paste data between input and output lists of processes as well as with other software such as Excel. The feature also works for parameter tables.

**Parameter overview:** The parameter overview lists all parameters in the active database regardless of whether they are local or global. Open it under Tools/Parameters. Upon opening the parameter overview, right-click and choose *Evaluate all formulas* allows to evaluate the underlying formulas. The filter field allows to search for specific parameters or to filter for errors. Via right-click and *Edit*, formulas can be changed directly from the parameter overview.

**Split view:** If you want to see two windows next to each other, drag the window header to the centre until a grey line, symbolizing the division of the windows, appears and drop it there.

nputs									0 ×
	2.0	(ä (t)	0.000	1 2 0002	Table of Sec.	Tar, see how		los a sua l	
Flow	Category	Amount		Costs/Reven	Service and a service of the service	Avoided wa		Data quality	Description
Fe drinking water Fe Granulates (PC, LDPE, PB), transp	Materials production/Wa A Water Bottle	1.00000	item(s)		none		P Drinking P PC Trans		
re Granulates (PC, LDPE, PB), transp	A water Bottle	1.00000	i nem(s)		none		P PC Irans		
						Ð			
			11						0 ×
Dutputs									• •
Flow	Category	Amount	Unit	Costs/Reven	Uncertainty	Avoided pr	Provider	Data quality	Description
PC Bottle, filled	A Water Bottle	1.06500	📼 kg		none				

General information Inputs/Outputs Administrative information Modeling and validation Parameters Allocation Social aspects Impact analysis Figure 59: Drag and drop window to open split view

ET Bottle Filling 83								PC Bottle Filling 🛛						-
nputs/Outputs: P	ET Bottle Fillin	ig					Ρ	Inputs/Outputs: PC	Bottle Filling					
Inputs				r Inputs										
Flow Fe drinking water Fe Granulates (PET, HD	Category Materials prod . A Water Bottle	Amount 1.00000 1.00000	🚥 kg	Costs/	Uncert none none	Avoide		Flow Fe drinking water Fe Granulates (PC, LDP	Category Materials prod A Water Bottle	Amount 1.00000 1.00000	📟 kg	Costs/	Uncert none none	Avoi
Outputs								- Outputs						
Flow Fe PET Bottle, filled	Category A Water Bottle	Amount 1.06500		Costs/	Uncert none	Avoide		Flow Fe PC Bottle, filled	Category A Water Bottle	Amount 1.06500		Costs/	Uncert none	Avoi

Figure 60: Windows opened in split view

Open provider: Right-click on a flow and select Open provider to navigate to the provider of a flow.

Category
Create new Remove selected Set as quantitative reference Copy Paste Open flow

Figure 61: Open provider of a flow

**Detached tabs:** Detach tabs and move them around on your screen as you like. Dragging and dropping a detached tab next to an existing tab in openLCA reverses the detaching. Detaching tabs allows you to run openLCA in single-window and multi-window mode. This is particularly handy when working with several screens.

Navigation % % % % % % % % % % % % % % % % % % %	<ul> <li>P apple production   ap</li> <li>P General inform</li> </ul>	pple   Cutoff, U - CL P appl	Close Others	
<ul> <li>Projects</li> <li>Product systems</li> <li>Processes</li> </ul>	+ General informati	ion	Close Tabs to the Left Close All	
<ul> <li>A:Agriculture, forestry and fi</li> <li>B:Mining and guarrying</li> </ul>	shin Name	apple production   apple	Detach	
<ul> <li>C:Manufacturing</li> <li>D:Electricity, gas, steam and</li> <li>E:Water supply, sewerage, w</li> <li>End of Life processes</li> <li>F:Construction</li> </ul>		market. Mineral NPK fertilise modelled within the project cover for each product at lea	r input is 30-20-40 kg/ha. No organic fertilis World Food LCA database (WFLDB). The ai ist 50% of the global export market. The exp	eld from 2009 - 2012 is 16.783 t/ha. The data are repr- ers are applied. Total active ingredients (ai.) applied m of this project was to provide inventories of a broa oors thare of apples produced in China amounts to 14 s produced in China for the export market:PEF-Qualit
<ul> <li>EConstruction</li> <li>G:Wholesale and retail trade;</li> <li>H:Transportation and storage</li> <li>J:Information and communic.</li> </ul>	Version	A:Agriculture, forestry and 03.02.000	fishing > 01:Crop and animal production, h	unting and related service activities > 012:Growing o
L:Real estate activities	UUID	de20bbdb-364a-30c9-8ee3-	14fd22173a80	
<ul> <li>M:Professional, scientific and</li> <li>N:Administrative and support</li> <li>S:Other service activities</li> </ul>	Last change	ss 🗀		
<ul> <li>Flows</li> <li>Indicators and parameters</li> </ul>		ris Create product system	Export to Excel	
> III Background data	+ Time			
	Start date 01/01/	/2009		
	End date 02/12/	/2017		
	Description			
	+ Geography			
	<			,

Figure 62: Detach a window

TE Navigation	P apple production   app	1-1 C					X				
TE Navigation % ***			<u> </u>								
<ul> <li>Projects</li> </ul>	P General inform	ation: apple pr	P apple production   app	ole Cutoff, U - CN 의							
<ul> <li>Product systems</li> <li>Processes</li> </ul>	* General informatio	n	P General inform	General information: apple production   apple   Cutoff, U							
<ul> <li>A:Agriculture, forestry and fishin</li> <li>B:Mining and guarrying</li> </ul>	Description This dataset representation		+ General informatio	* General information							
> E:Manufacturing				apple production   apple   Cutoff, U This dataset represents the production of 1 kg of apples. The average yield from 2009 - 2012 is 16,783 t/ha. The data ar market. Mineral NPK fertiliser input is 30-20-40 kg/ha. No organic fertilisers are applied. Total active ingredients (a.i.) ap modelled within the project. World Food LCA database (WFLDB). The aim of this project was to provide inventories of a cover for each product at less 55% of the pioloal export market. The export share of apples produced in China amounts							
<ul> <li>D:Electricity, gas, steam and air c</li> <li>E:Water supply, sewerage, waste</li> <li>End of Life processes</li> <li>F:Construction</li> </ul>			Description								
> 🖿 G:Wholesale and retail trade; re;	Category	A:Agriculture, fo				apples produced in China for the export market;P					
<ul> <li>H:Transportation and storage</li> <li>J:Information and communicatic</li> <li>L:Real estate activities</li> </ul>	Version	03.02.003 🕤 🔅	Category	A:Agriculture, forestry and	d fishing > 01:Crop and animal produ	ction, hunting and related service activities > 012:0	Srowine				
	UUID	fd778775-7908-3f	Version	03.02.000 🕤 🗉							
<ul> <li>M:Professional, scientific and tec</li> <li>N:Administrative and support se</li> </ul>	Last change	2019-04-02T15:39:2	UUID	de20bbdb-364a-30c9-8ee3	I-14fd22173a80						
> ESOther service activities	Infrastructure process		Last change								
<ul> <li>Elows</li> <li>Indicators and parameters</li> </ul>		ra Create product	Infrastructure process								
<ul> <li>III Background data</li> </ul>	- Time	-		rio Create product system	SE Export to Excel						
	Start date 01/01/2	009	- Time								
	End date 02/12/2	017	Start date 01/01/2	009							
	Description		End date 02/12/2								
	Description						_				
	+ Geography		Description								
	* Geography										

Figure 63: Detached windows

**Memory usage:** Some databases require higher memory usage (e.g. ecoinvent 3) for the calculations. Change it under File/Preferences/Configuration.

**Language:** openLCA is available in Arabic, Bulgarian, Catalan, Chinese, English, French, German, Italian, Portuguese, Spanish and Turkish. Change it under File/Settings/Configuration. Once you change the language, restart the program to activate it.

C Preferences		- 🗆 X
type filter text	Configuration	
Collaboration Configuration Experimental features Import/Export Logging Number format	Language Maximum memory usage in MB	Turkish       ✓         24000
		Apply and Close Cancel

Figure 64: Language and memory usage configuration

12 openLCA and LCA support <u>GreenDelta GmbH</u>, the developer of openLCA, offers openLCA users prioritised and guaranteed professional openLCA support via the GreenDelta helpdesk (<u>https://www.openlca.org/helpdesk/</u>). Free (User2User) support for openLCA is available via <u>https://ask.openlca.org/</u>.

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