openLCA Tutorial
Basic Modelling in openLCA

Software Version: 1.10

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GreenDelta

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1 Introduction

openLCA is the open-source software 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 (openlca.org), 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 Nexus web 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 openLCA website.

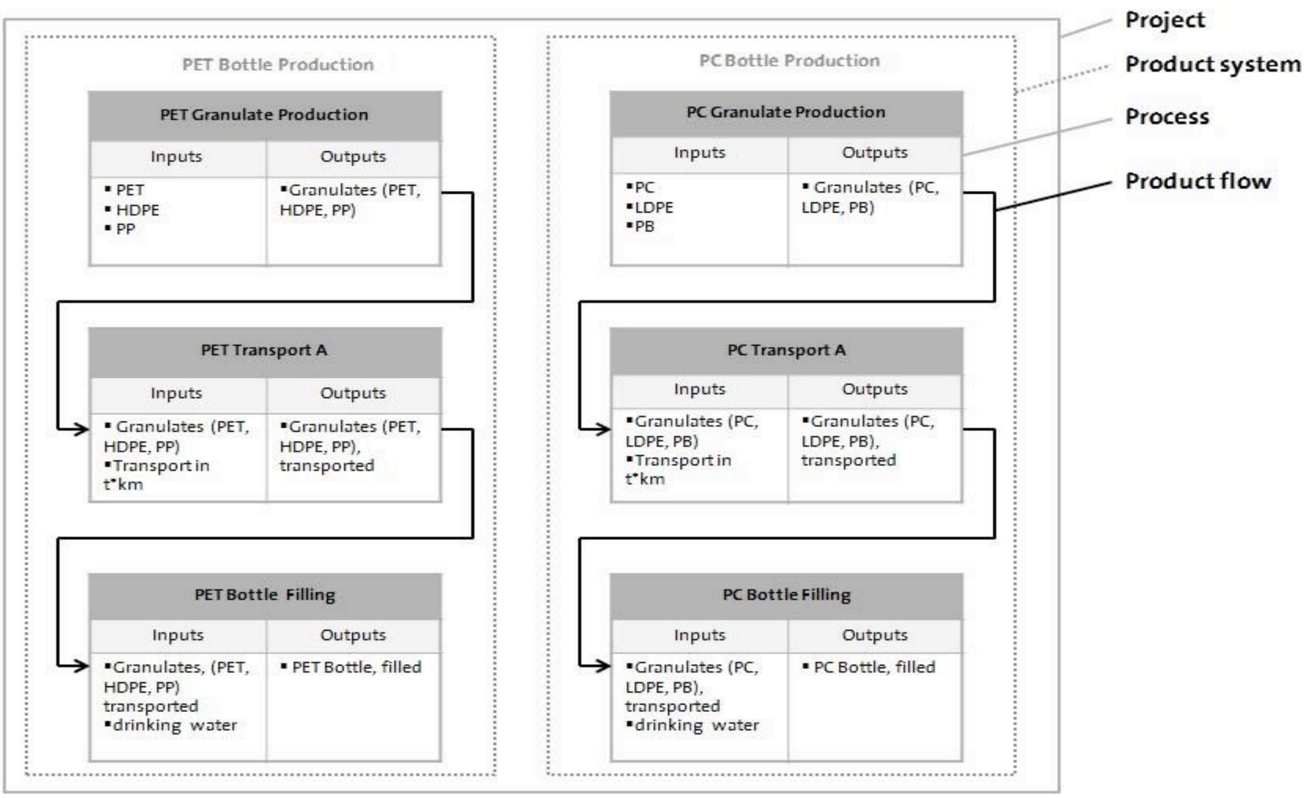
The database bottle tutorial with all elements created within this tutorial can be downloaded here.

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:

- 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 A*dd 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*.

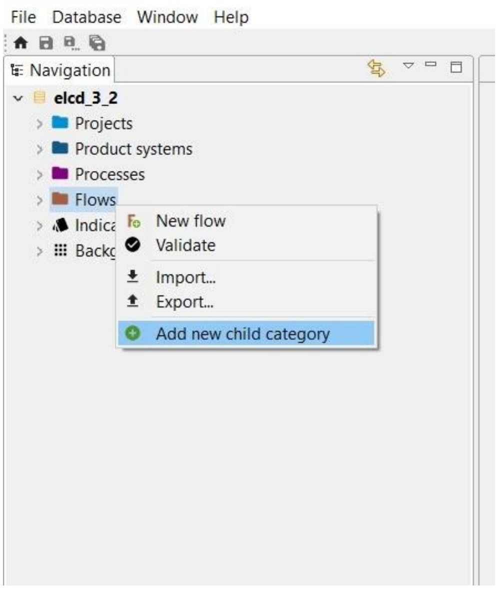


Figure 2: Create a new folder

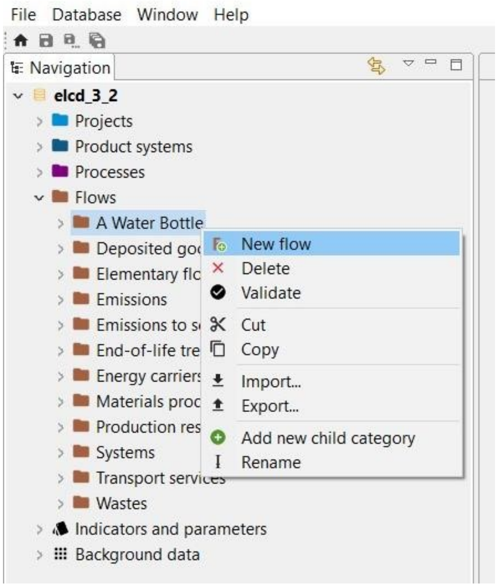


Figure 3: Create a new flow

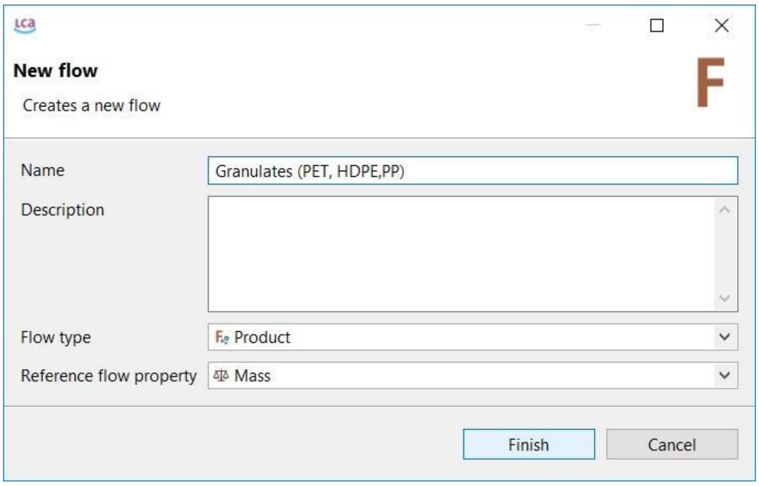


Figure 4: Name, flow type and reference flow property of a new flow

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.

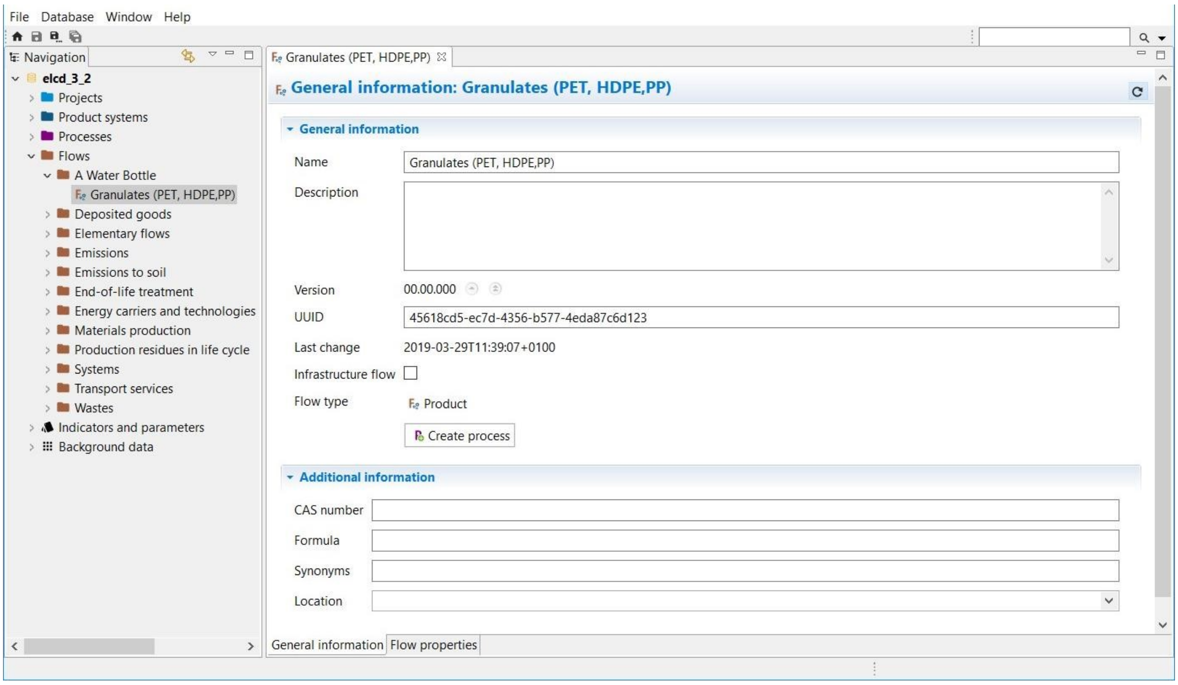


Figure 5: New flow in the Navigation and Editor window

Now create more flows according to Table 1.

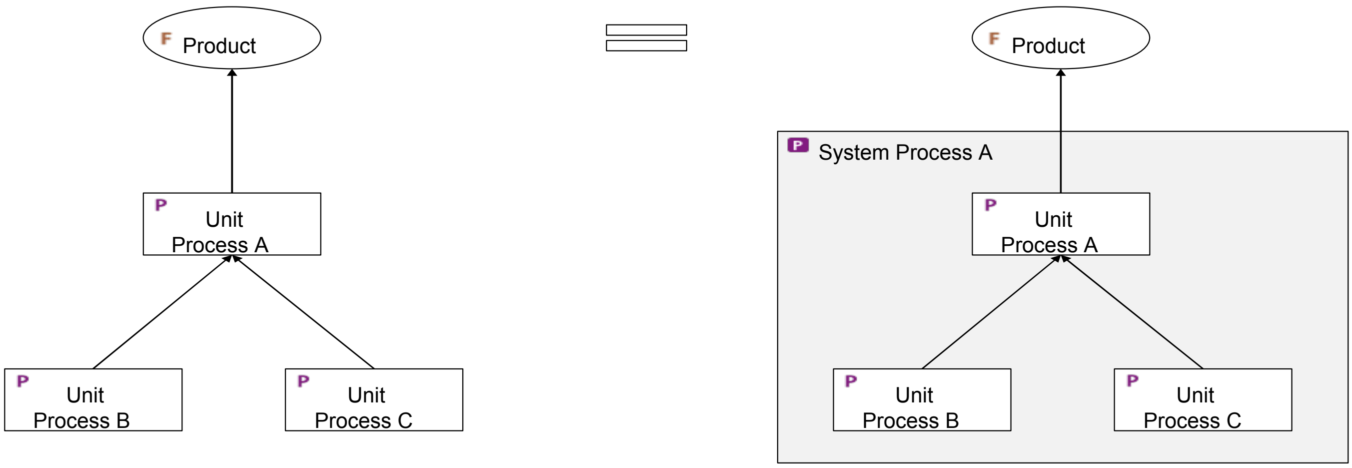
Table 1: Inputs for creating new flows

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*.

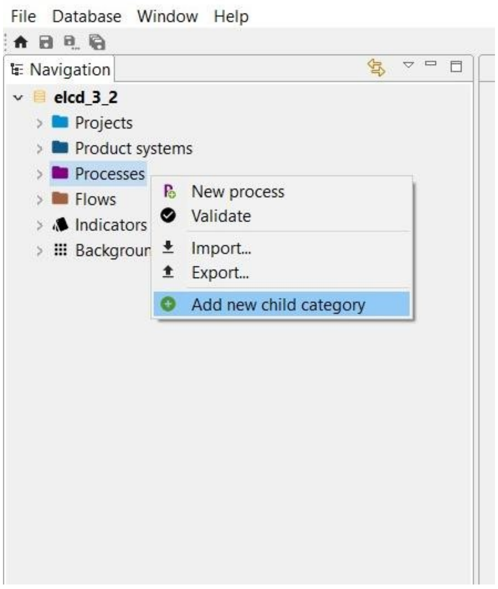


Figure 7: Create a new folder

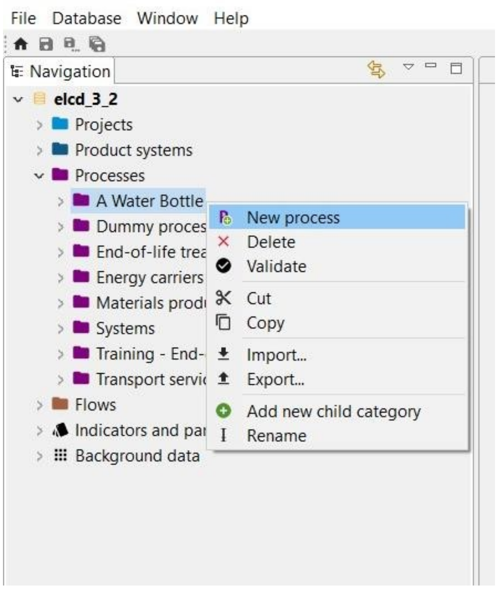


Figure 8: Create a new process

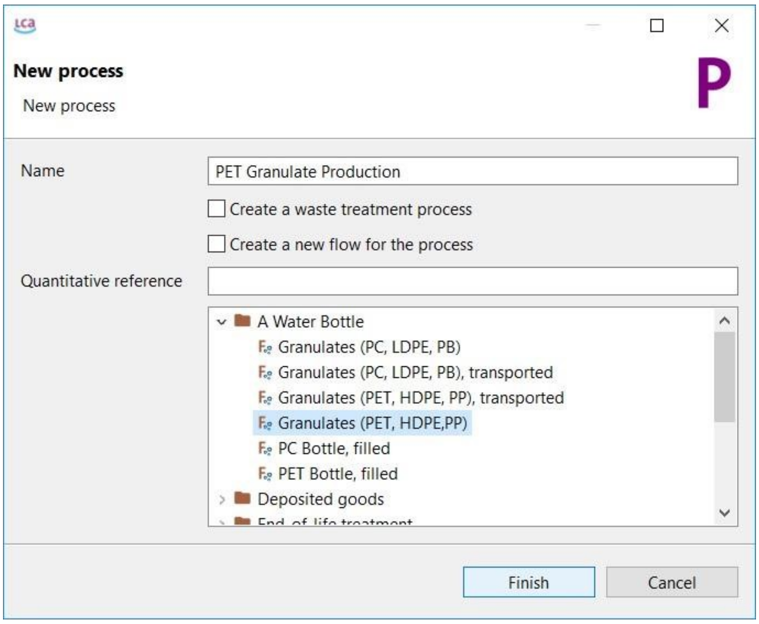


Figure 9: Name and quantitative reference of a new process

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.

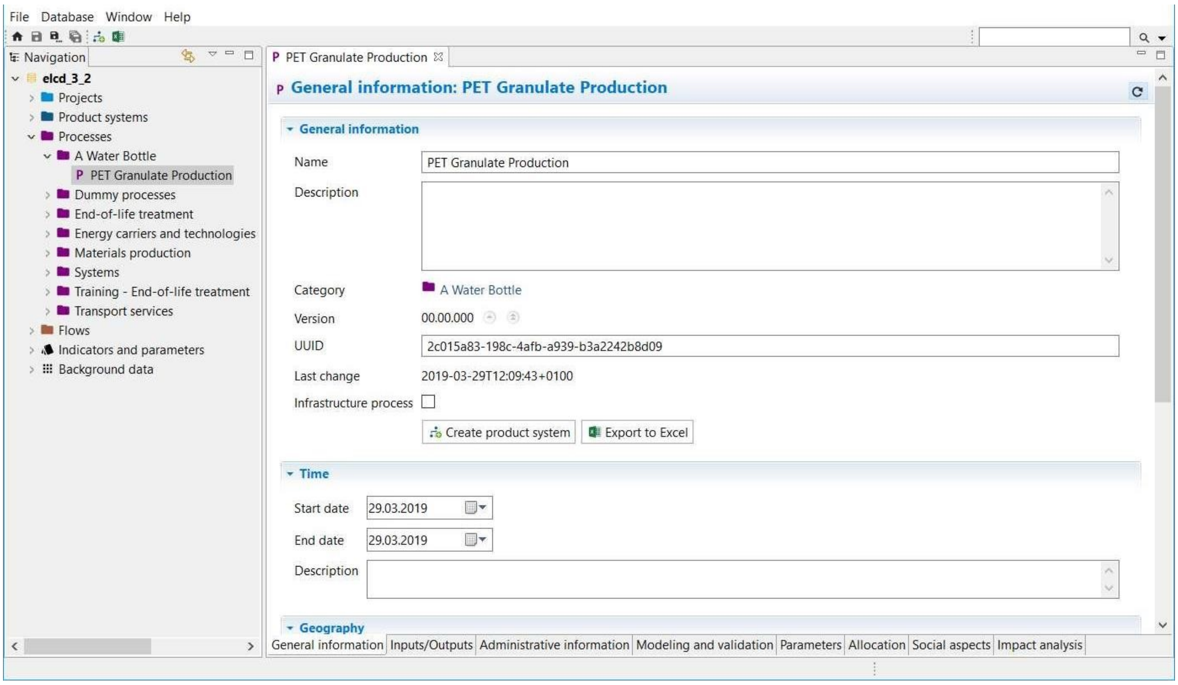


Figure 10: New Process in the Navigation and Editor window

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	Quantitative reference	Input Flows	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

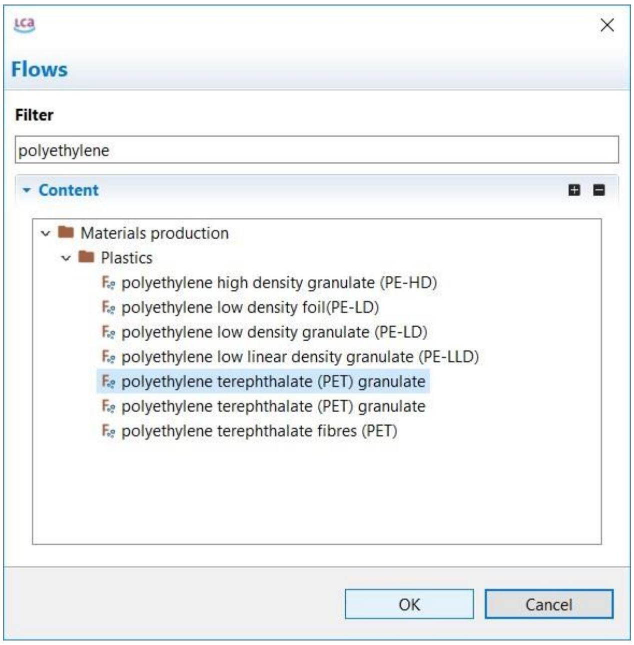


Figure 11: Adding input flows by using the flow filter

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.

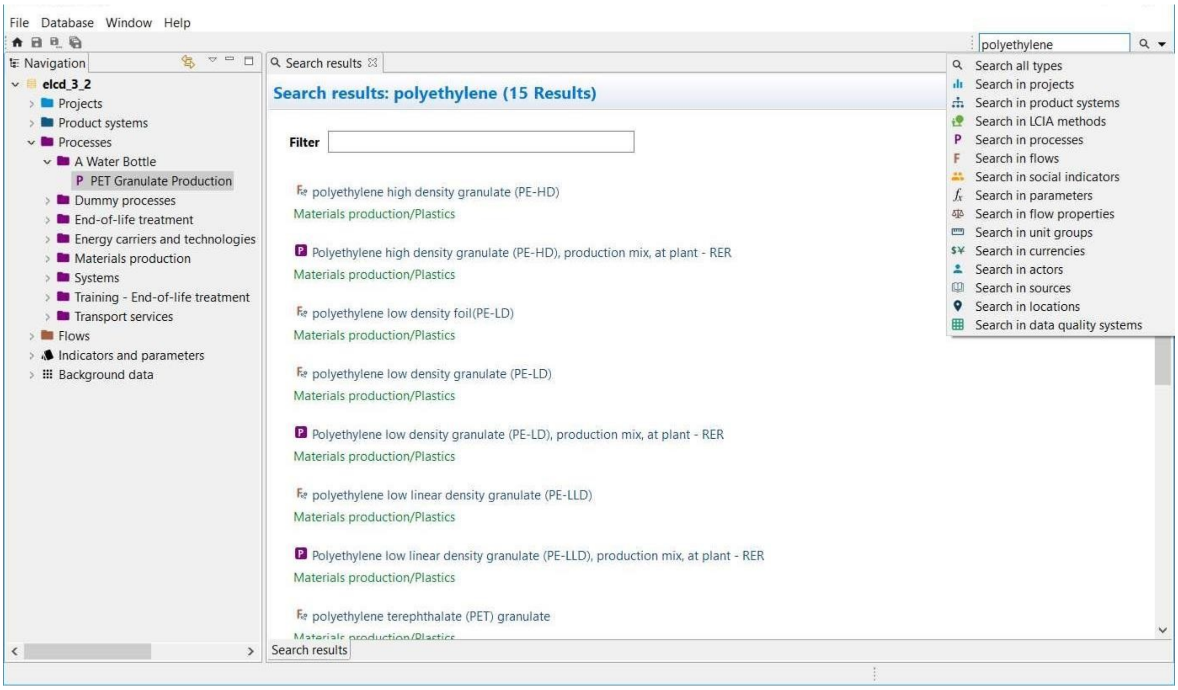


Figure 12: Search function

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.

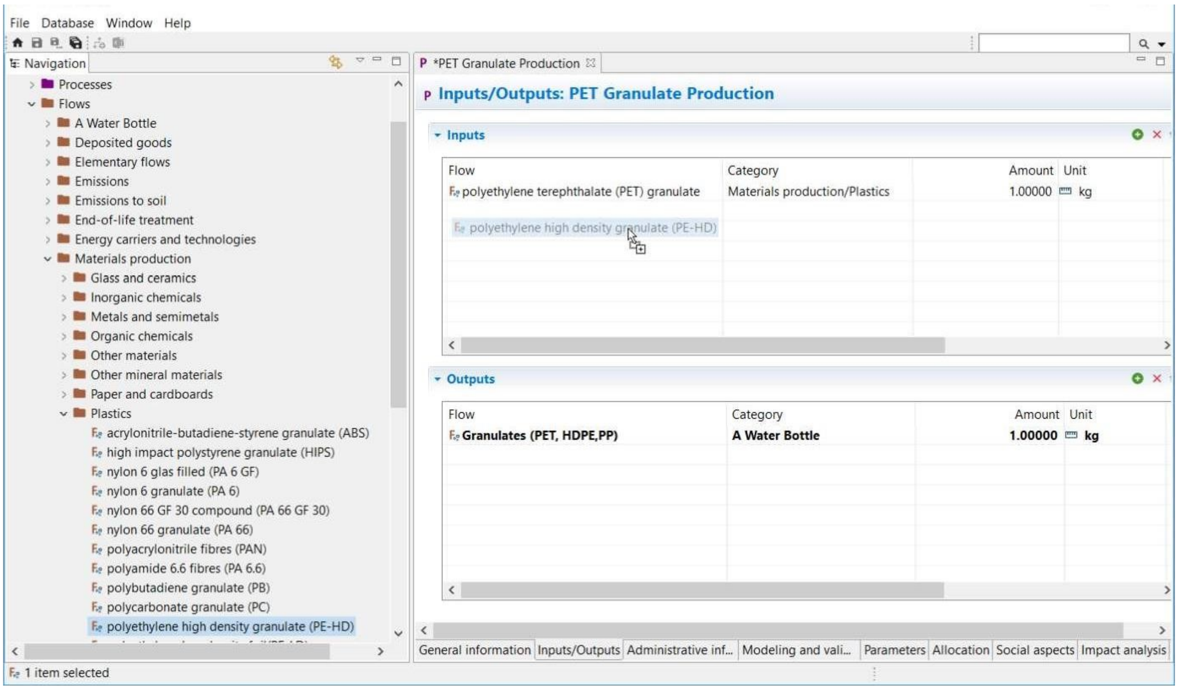


Figure 13: Adding input flows from the Navigation window by using drag and drop

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.

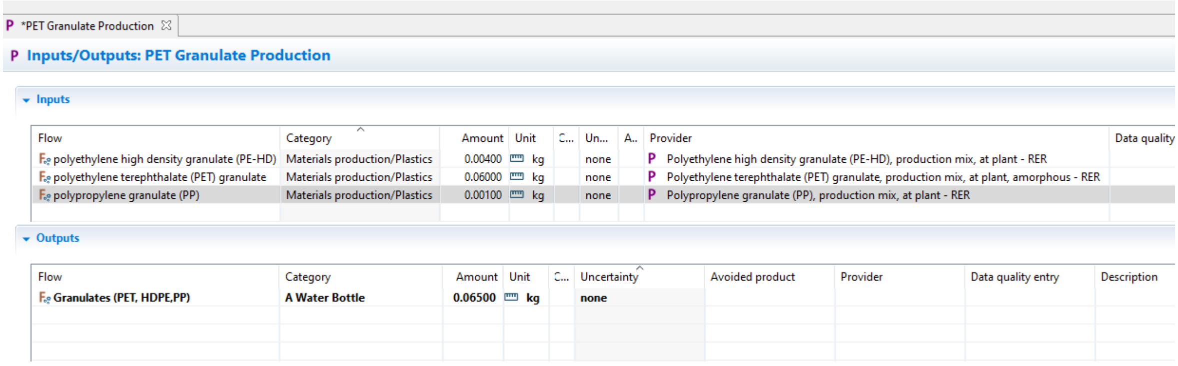


Figure 14: Inputs/Outputs tab of the process editor for the process *PET Granulate Production*

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*.

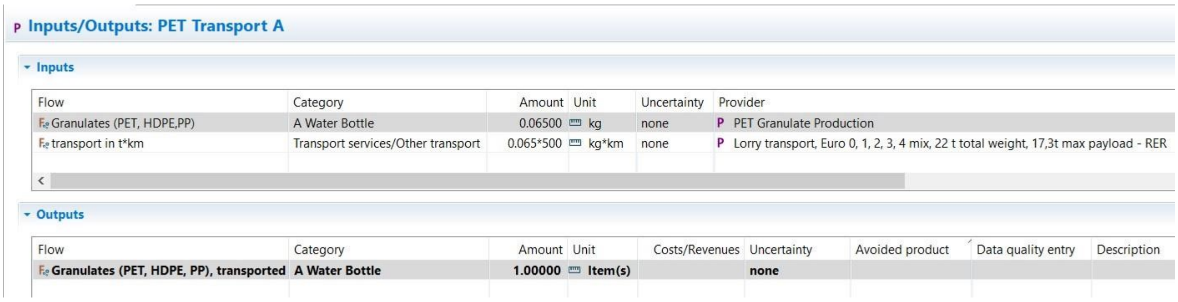


Figure 15: Inputs/Outputs tab of the process editor for the process *PET Transport A*

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

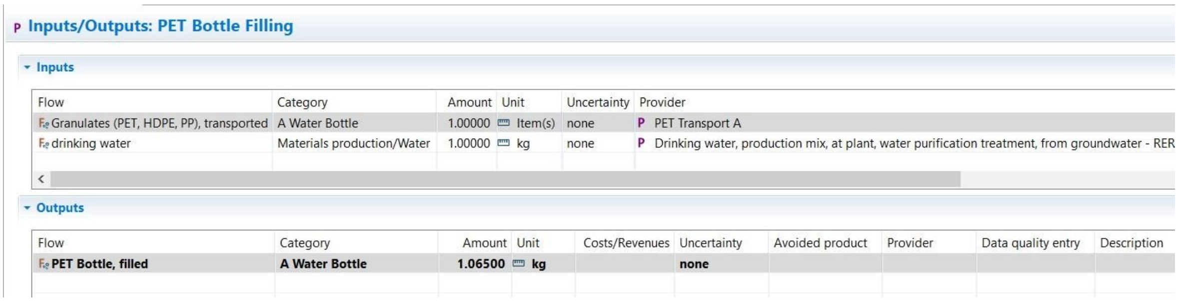


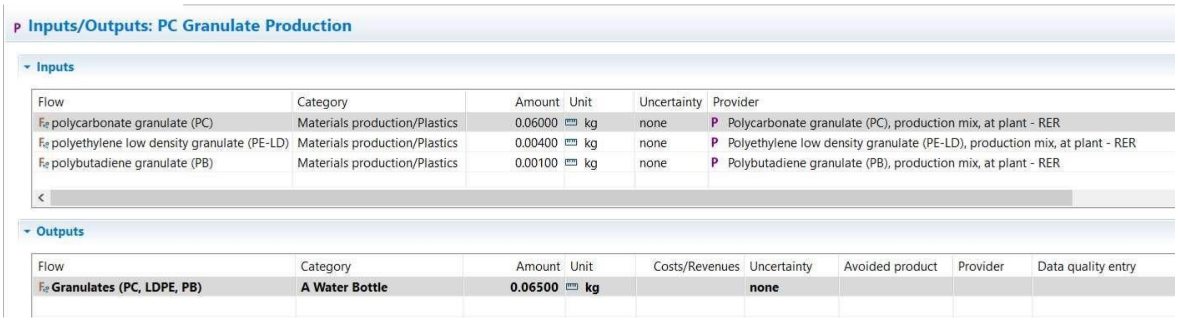
Figure 16: Inputs/Outputs tab of the process editor for the process *PET Bottle Filling*

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.

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

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

		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/Outputs: PC Granulate Production

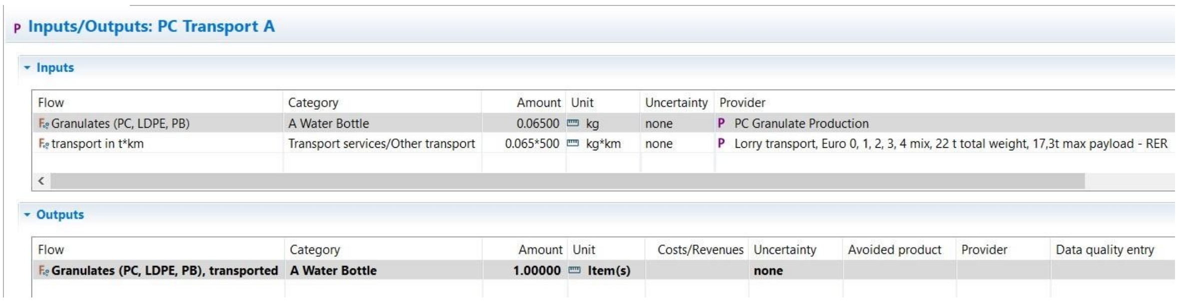
Inputs

Flow	Category	Amount	Unit	Uncertainty	Provider
polycarbonate granulate (PC)	Materials production/Plastics	0.06000	kg	none	Polycarbonate granulate (PC), production mix, at plant - RER
polyethylene low density granulate (PE-LD)	Materials production/Plastics	0.00400	kg	none	Polyethylene low density granulate (PE-LD), production mix, at plant - RER
polybutadiene granulate (PB)	Materials production/Plastics	0.00100	kg	none	Polybutadiene granulate (PB), production mix, at plant - RER

Outputs

Flow	Category	Amount	Unit	Costs/Revenues	Uncertainty	Avoided product	Provider	Data quality entry
Granulates (PC, LDPE, PB)	**A Water Bottle**	**0.06500**	**kg**		**none**			

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


Inputs/Outputs: PC Transport A

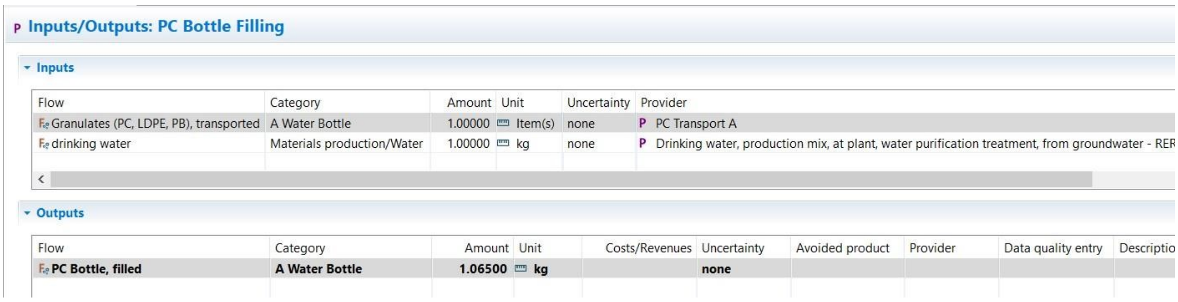
Inputs

Flow	Category	Amount	Unit	Uncertainty	Provider
Granulates (PC, LDPE, PB)	A Water Bottle	0.06500	kg	none	PC Granulate Production
transport in t*km	Transport services/Other transport	0.065*500	kg*km	none	Lorry transport, Euro 0, 1, 2, 3, 4 mix, 22 t total weight, 17,3t max payload - RER

Outputs

Flow	Category	Amount	Unit	Costs/Revenues	Uncertainty	Avoided product	Provider	Data quality entry
Granulates (PC, LDPE, PB), transported	**A Water Bottle**	**1.00000**	**Item(s)**		**none**			

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


Inputs/Outputs: PC Bottle Filling

Inputs

Flow	Category	Amount	Unit	Uncertainty	Provider
Granulates (PC, LDPE, PB), transported	A Water Bottle	1.00000	Item(s)	none	PC Transport A
drinking water	Materials production/Water	1.00000	kg	none	Drinking water, production mix, at plant, water purification treatment, from groundwater - RER

Outputs

Flow	Category	Amount	Unit	Costs/Revenues	Uncertainty	Avoided product	Provider	Data quality entry	Descriptio
PC Bottle, filled	**A Water Bottle**	**1.06500**	**kg**		**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.

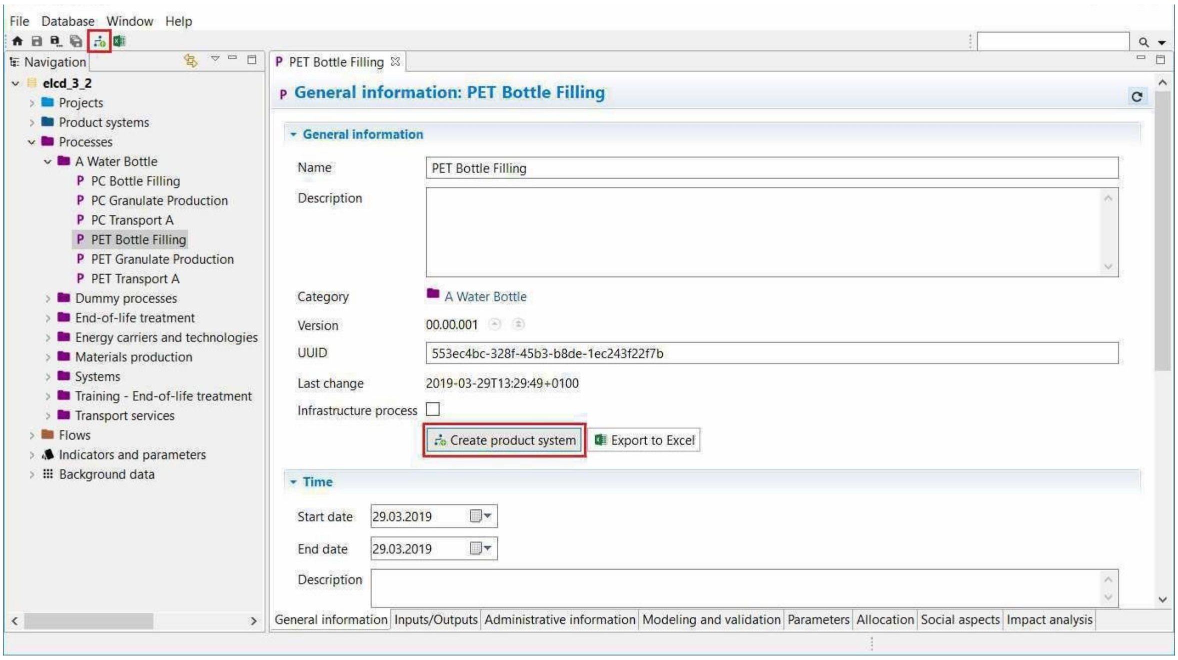


Figure 20: Create a product system in the process editor

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.

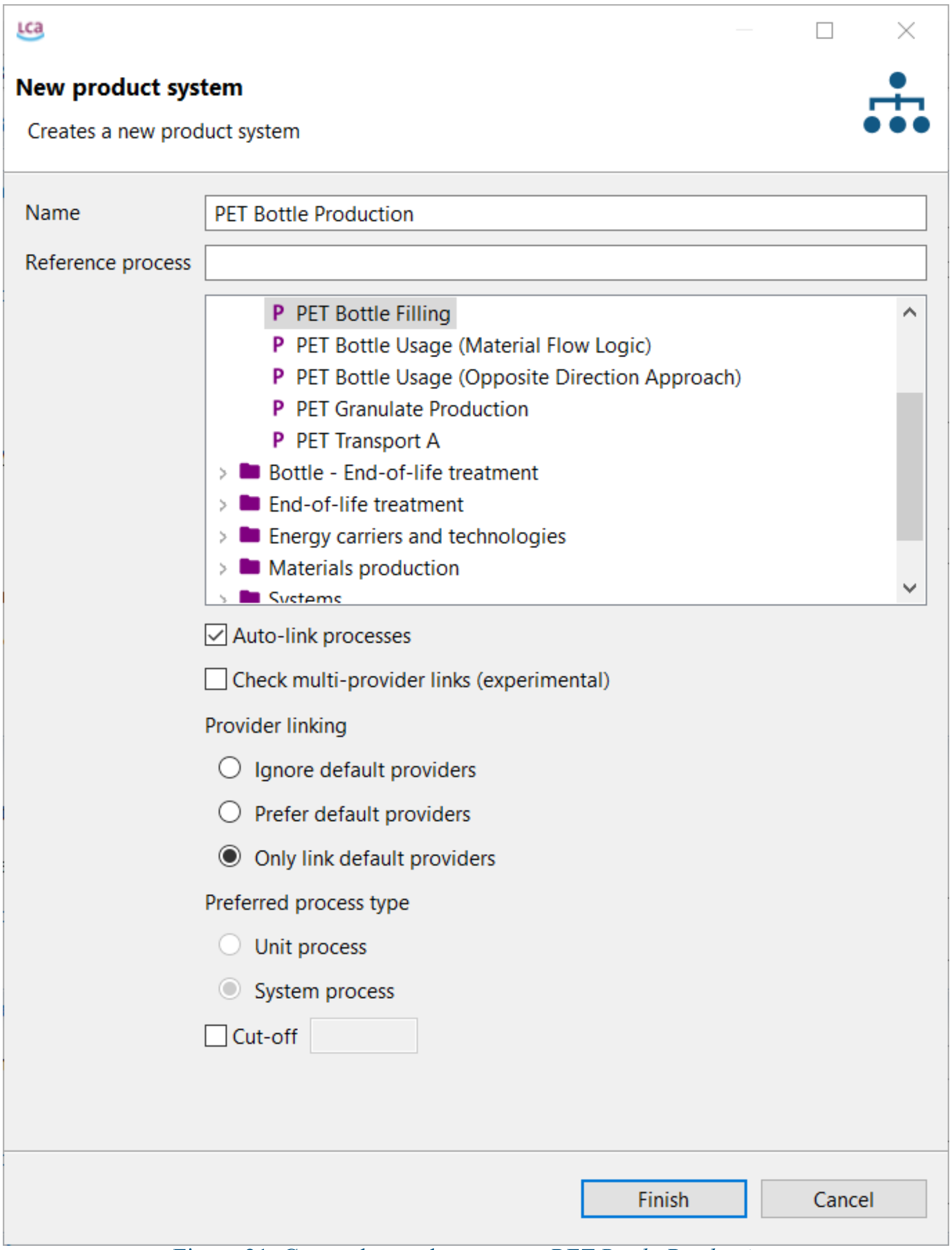


Figure 21: Create the product system *PET Bottle Production*

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.

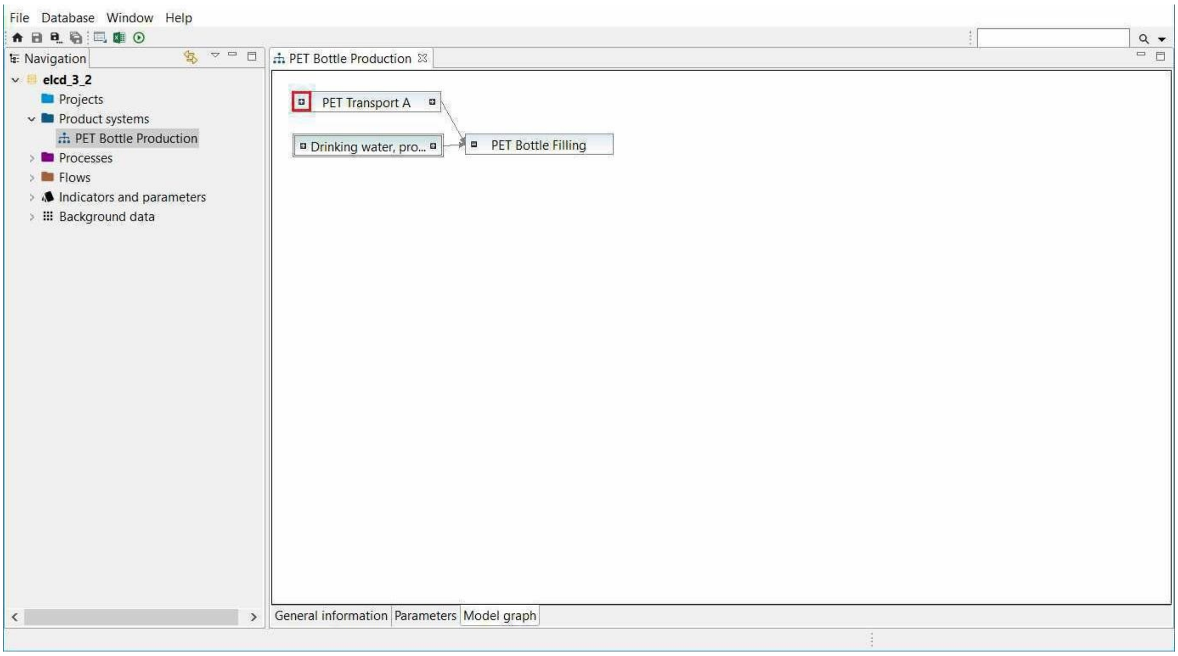


Figure 22: *Model graph* of the product system *PET Bottle Production*

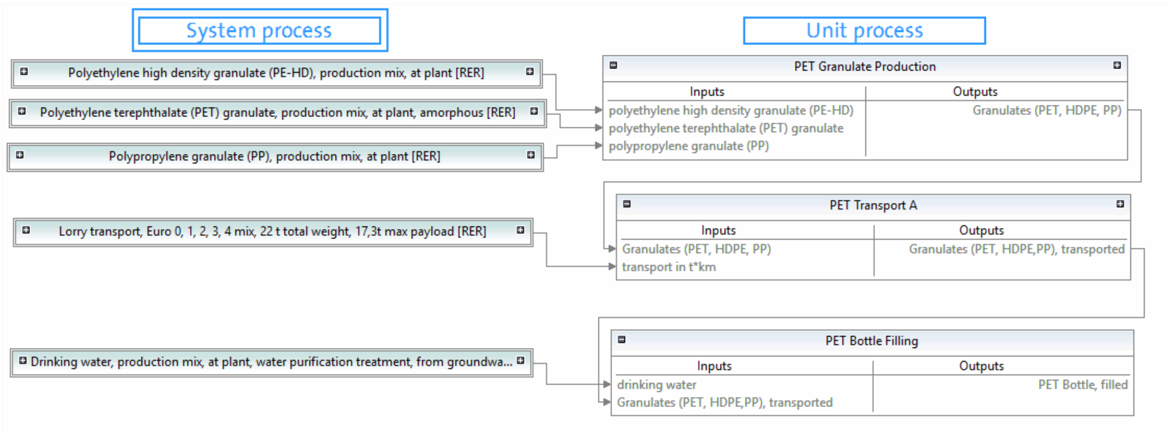


Figure 23: System and unit processes of the product system *PET Bottle Production*

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.

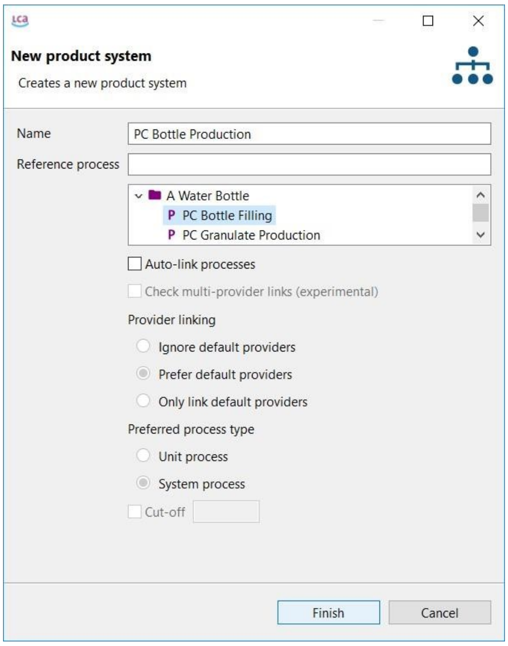


Figure 24: Create the product system *PC Bottle Production*

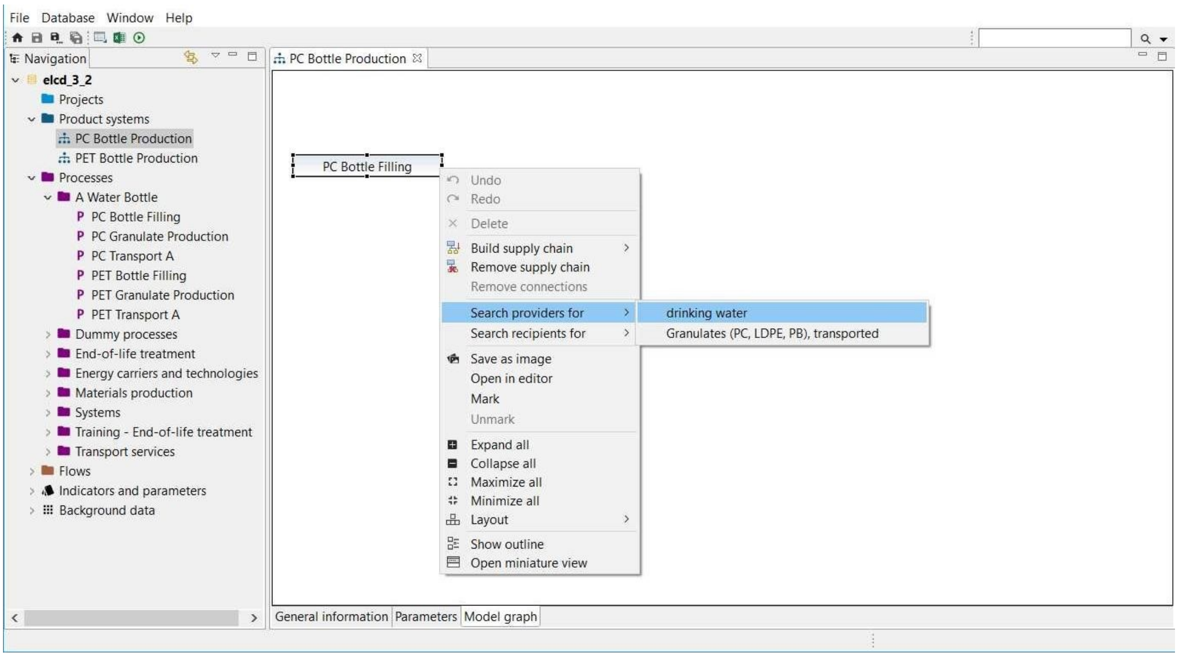


Figure 25: Model graph of the product system *PC Bottle Production*

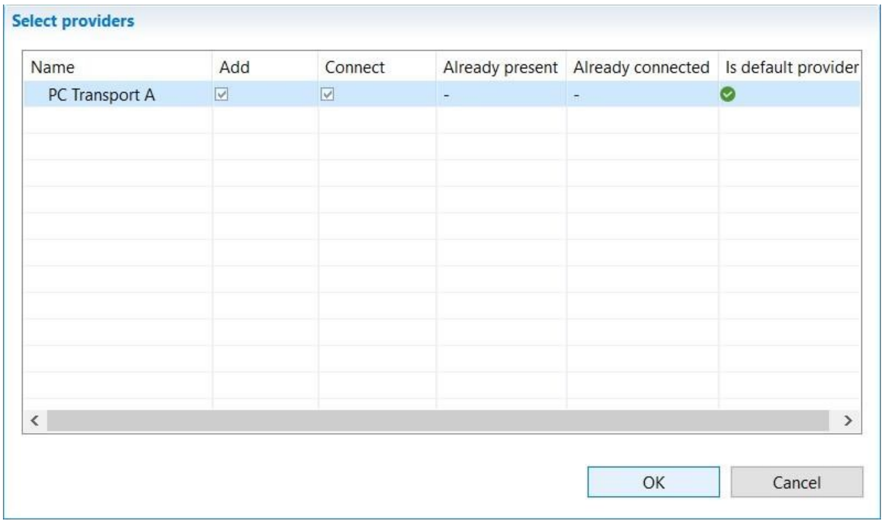


Figure 26: Select providers of the product system *PC Bottle Production*

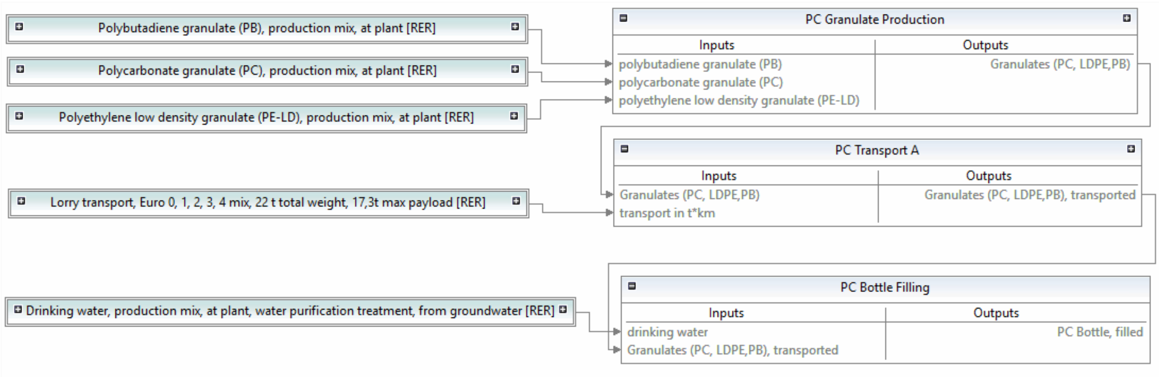


Figure 27: System and unit processes of the product system *PC Bottle Production*

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.

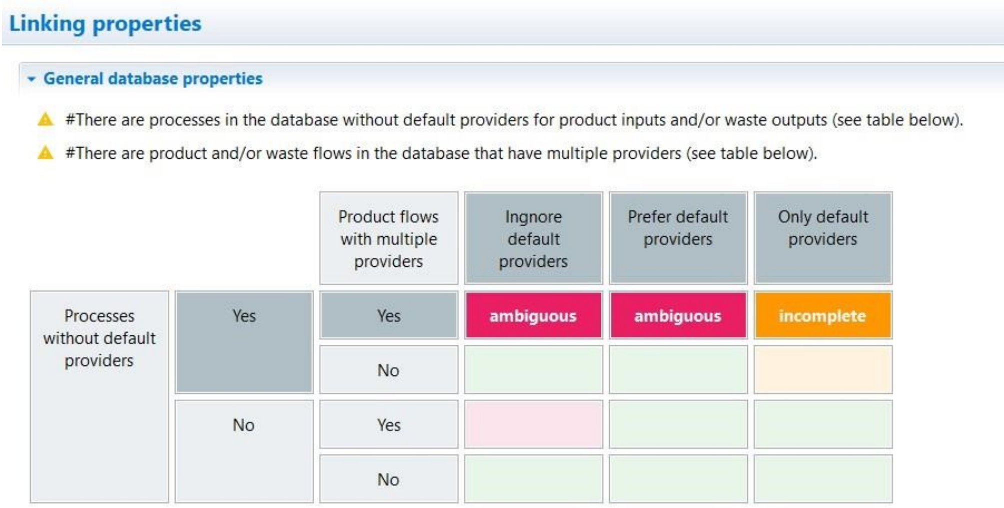


Figure 28: Linking properties

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.

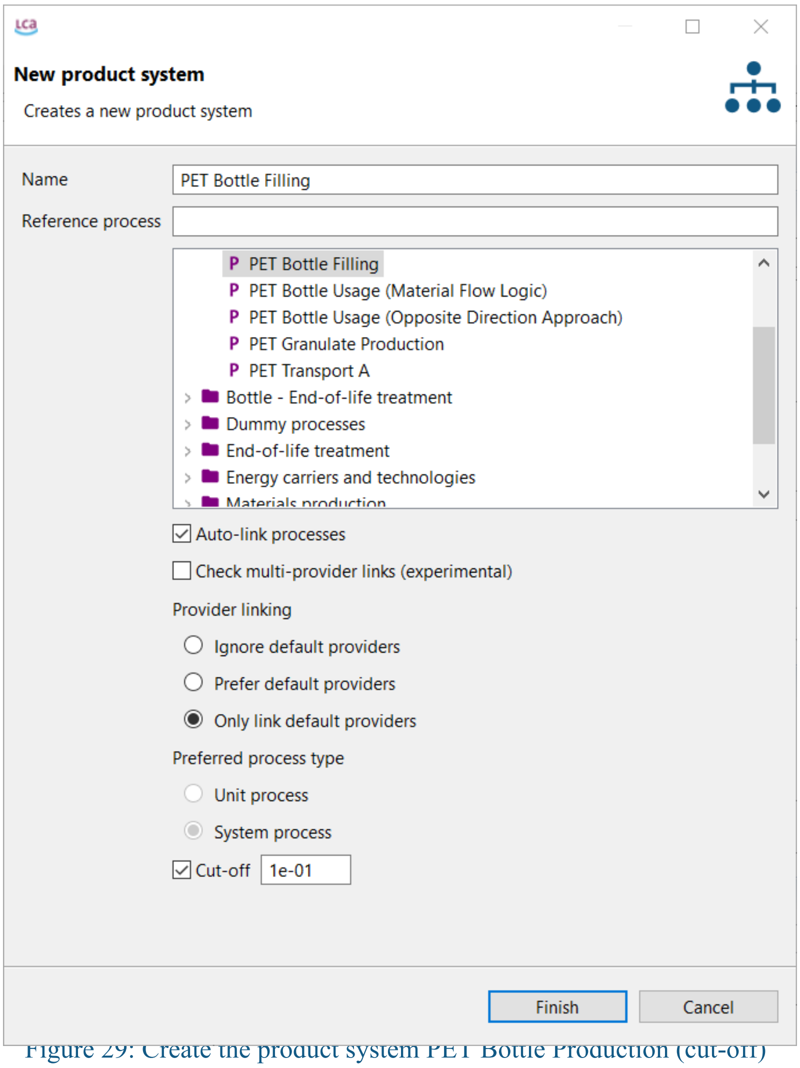


Figure 29: Create the product system PET Bottle Production (cut-off)

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*.

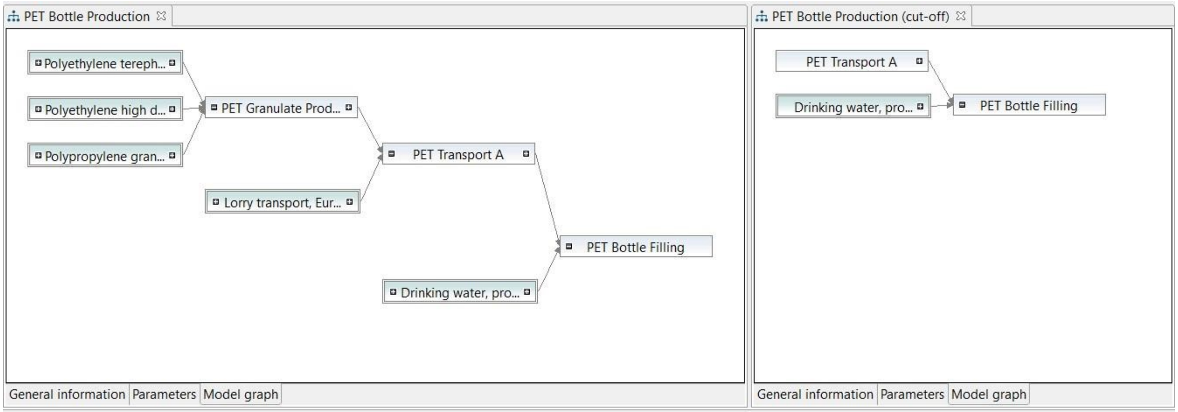


Figure 30: Model graph of the *PET Bottle Production* and the *PET Bottle Production (cut-off)*

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*.

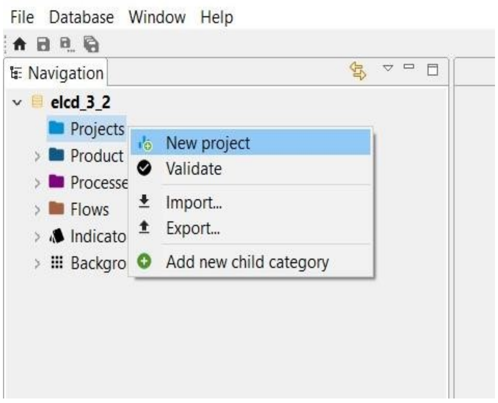


Figure 31: Create a new project

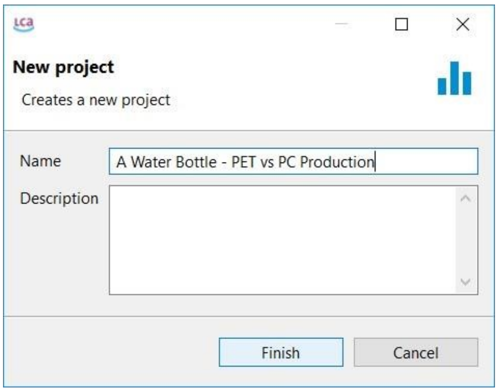


Figure 32: Name of a new project

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*.

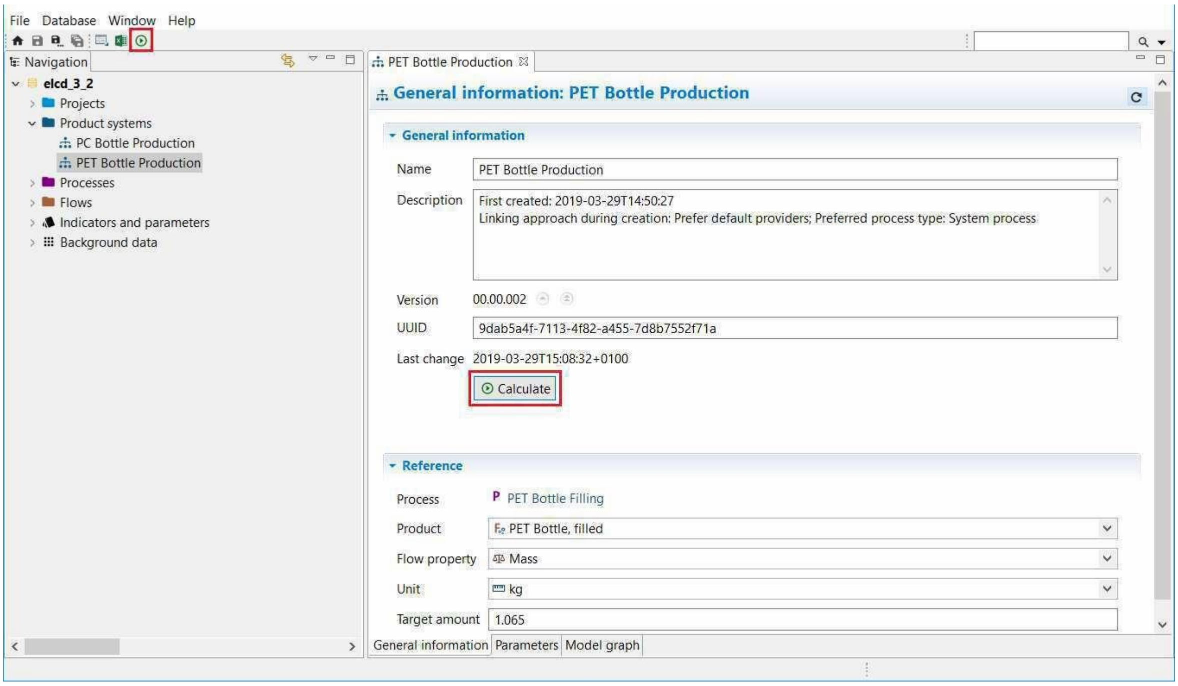


Figure 33: Calculate a product system

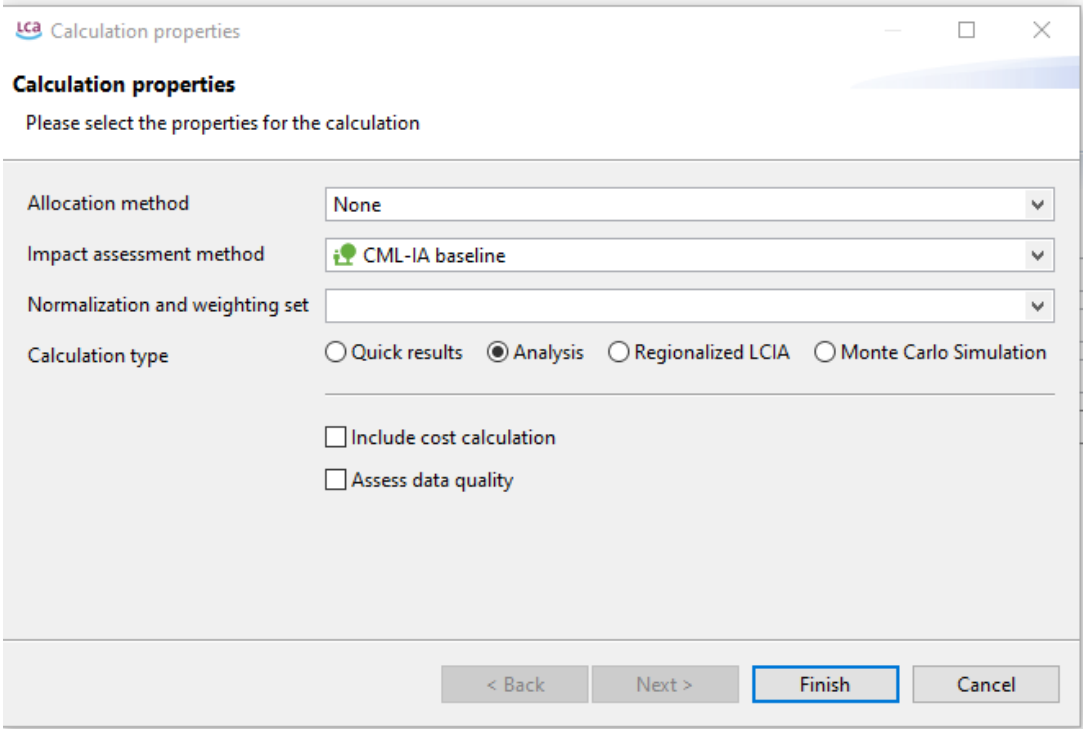


Figure 34: Calculation properties

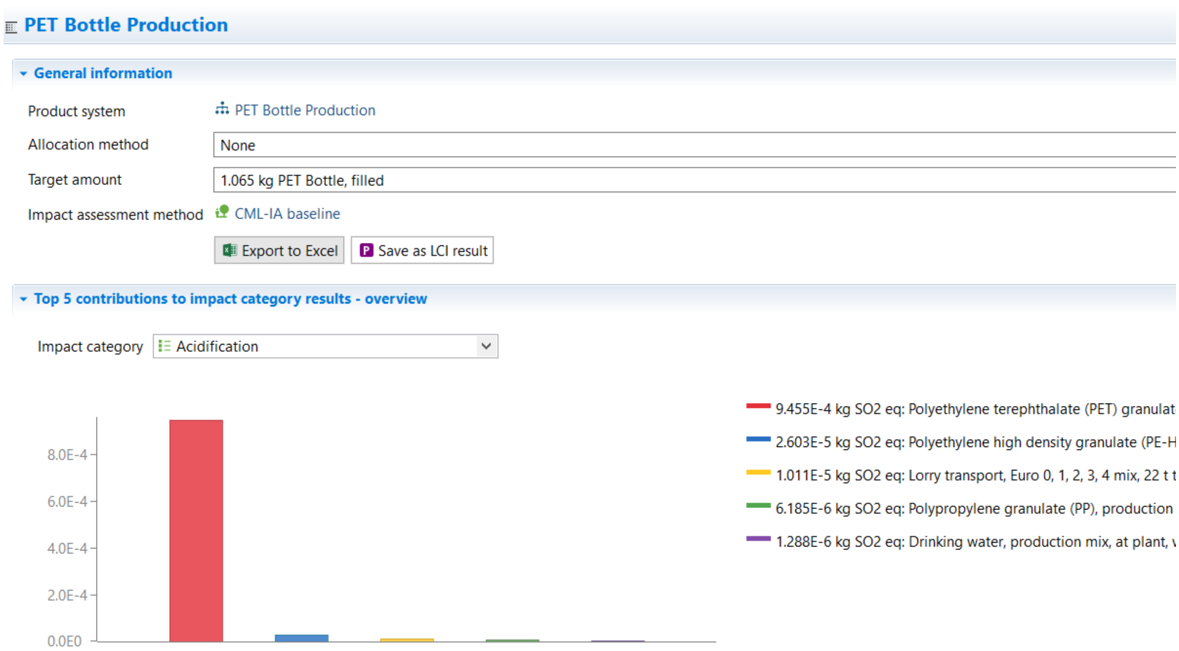


Figure 35: Direct contribution for each flow and each impact category

PET Bottle Production

Impact analysis: CML-IA baseline

Subgroup by processes ☑ Don't show < 1 %

Name	Category	Inventory result	Impact factor	Impact result	Unit
Acidification				0.00099	kg SO...
Photochemical oxidation				6.40905E-5	kg C2...
Fresh water aquatic ecotox.				0.00027	kg 1,4...
Ozone layer depletion (ODP)				1.15288E-11	kg CF...
Abiotic depletion				2.10139E-9	kg Sb...
Terrestrial ecotoxicity				4.97674E-5	kg 1,4...
Abiotic depletion (fossil fuels)				0.00000	MJ
Global warming (GWP100a)				0.21211	kg CO...
Marine aquatic ecotoxicity				16.03829	kg 1,4...
Eutrophication				6.51249E-5	kg PO...
Human toxicity				0.01590	kg 1,4...

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.

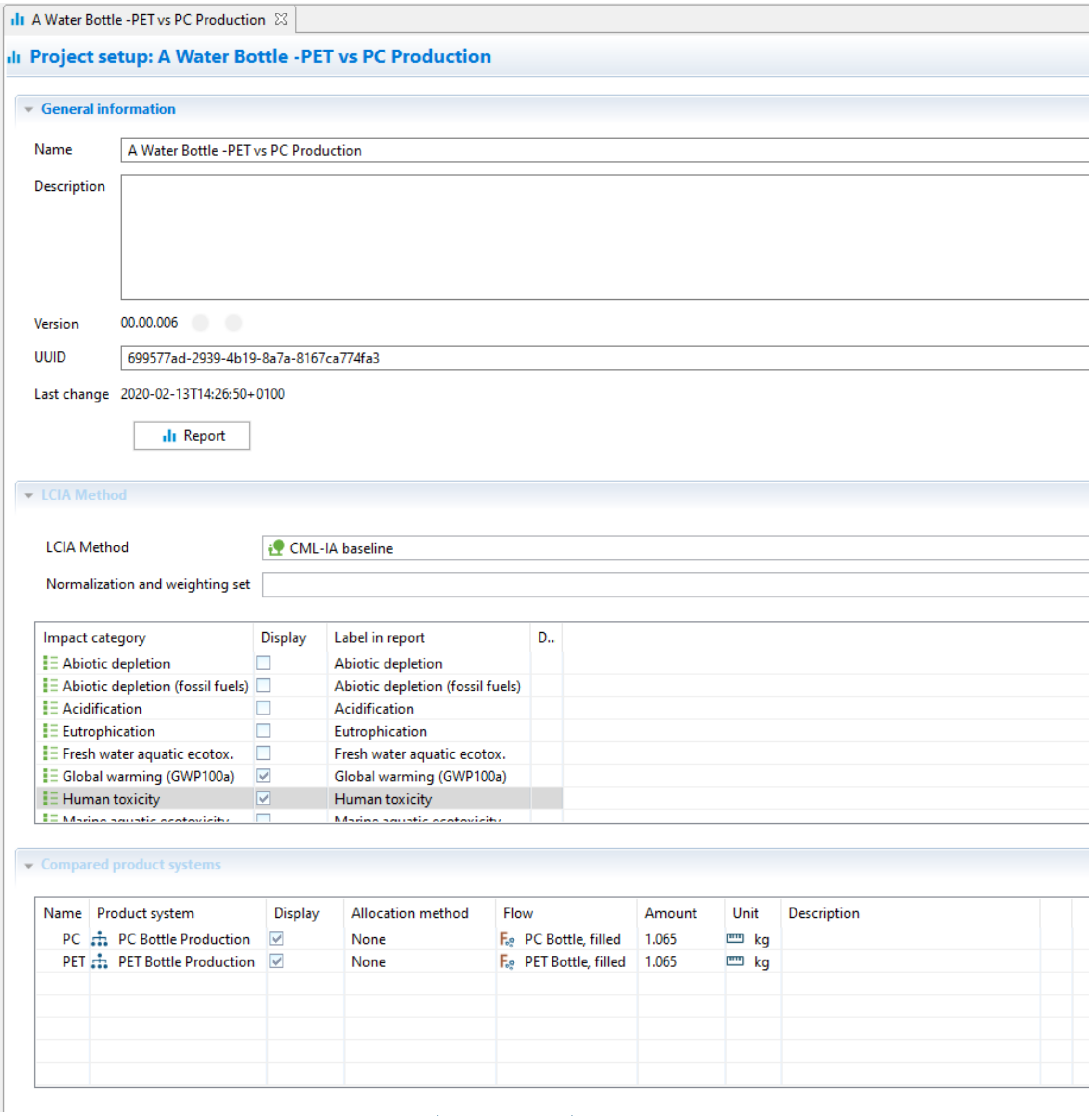


Figure 37: Project setup

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.

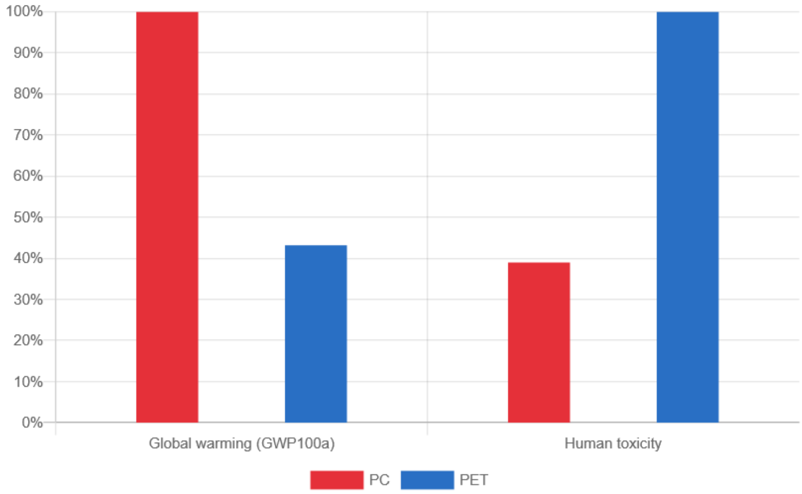


Figure 38: Relative results of the compared product system for the selected impact categories

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*.

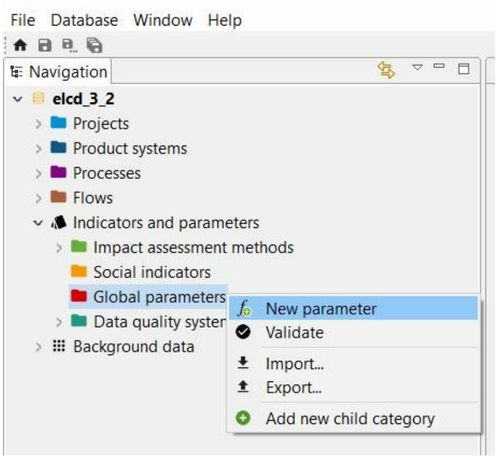


Figure 39: Create a new global parameter

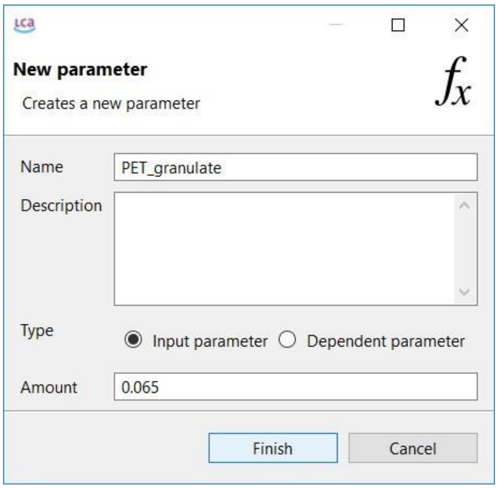


Figure 40: Name and amount of a new parameter

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*.

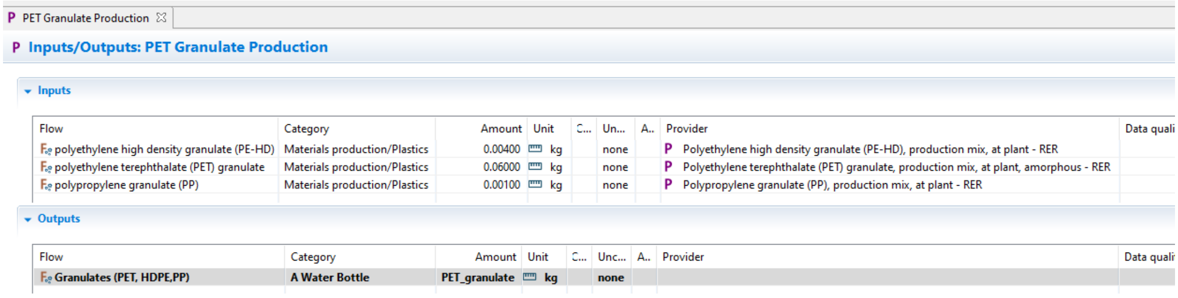


Figure 41: Inputs/Outputs tab of the process *PET Granulate Production*

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.

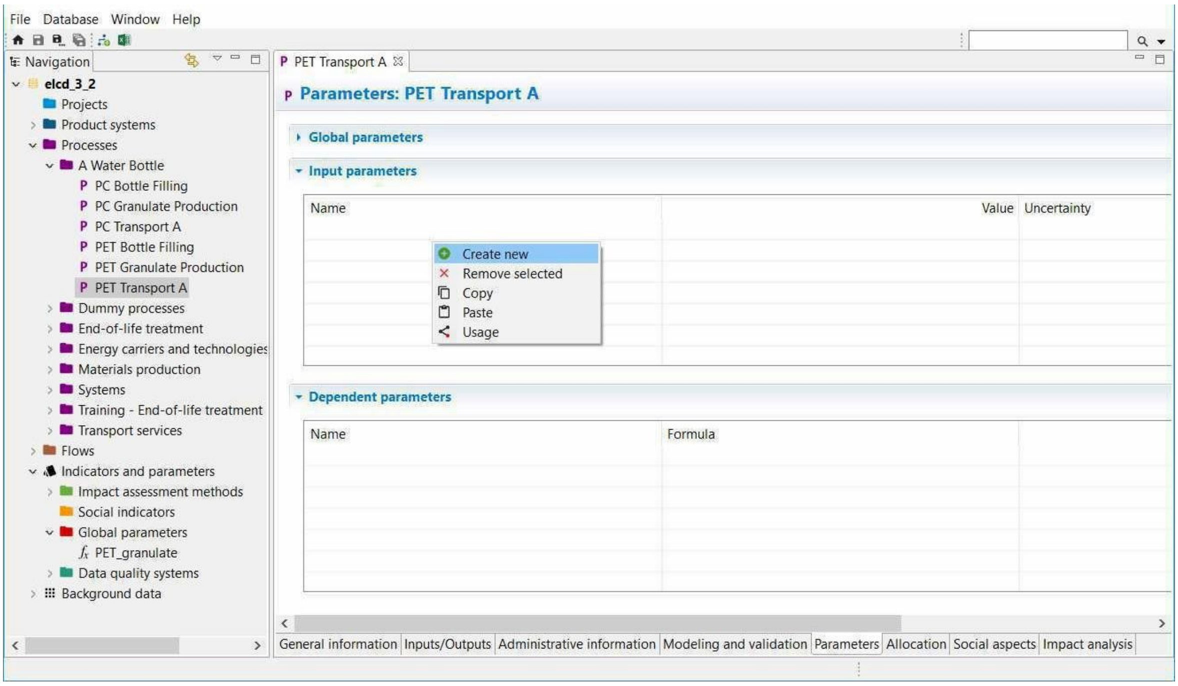


Figure 42: Create a new local parameter

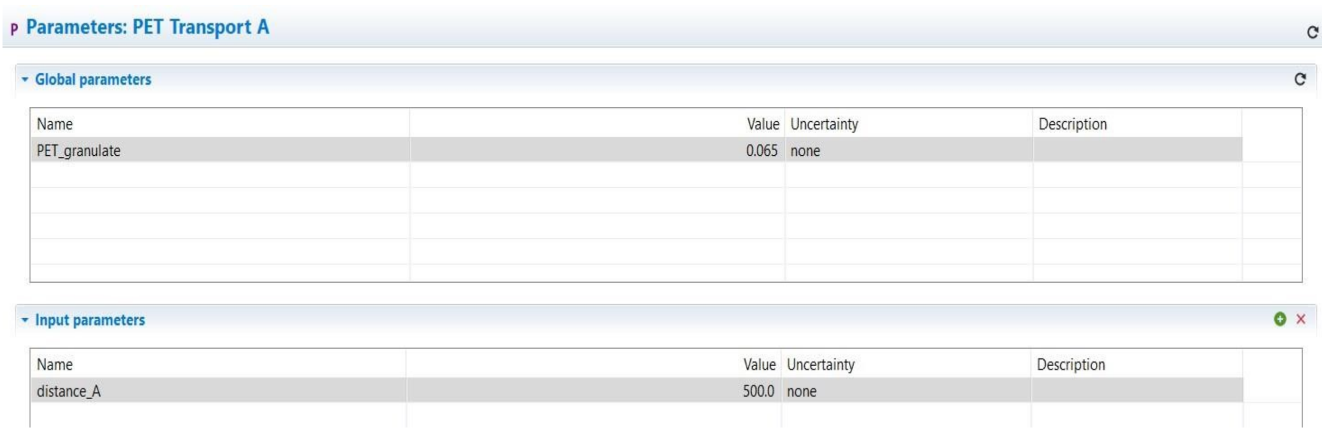


Figure 43: Parameters tab

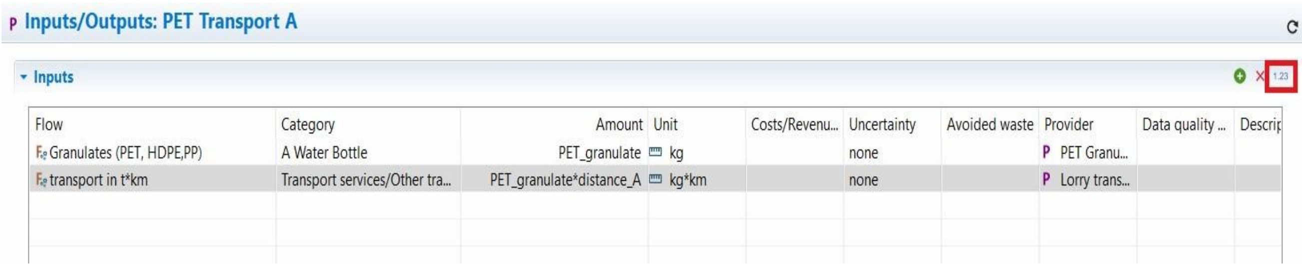


Figure 44: Inputs/Outputs tab of the process *PET Transport A*

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.

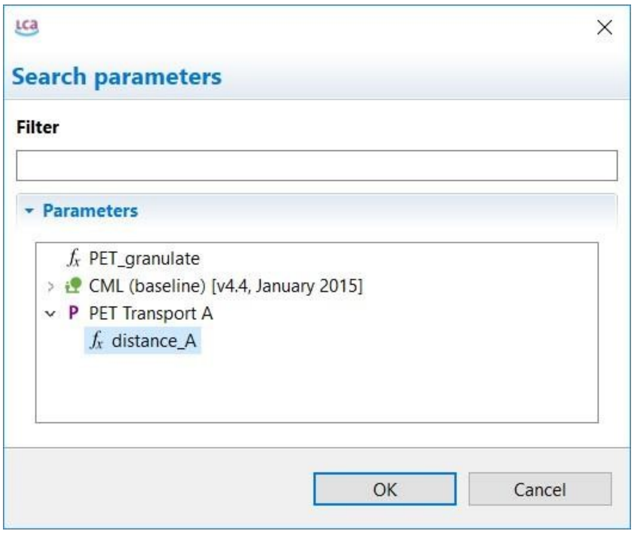


Figure 45: Add parameters to a project

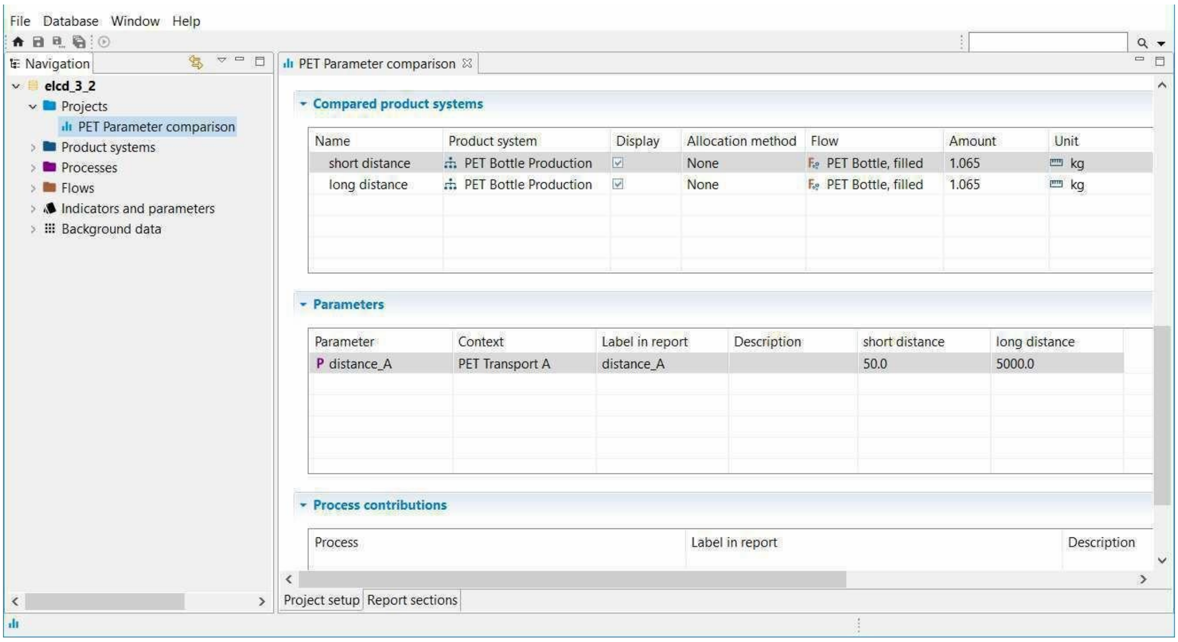


Figure 46: Project *PET Parameter comparison*

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 here. After, you have imported the file, you should find the respective processes in the folder *Bottle - End-of-life treatment.*

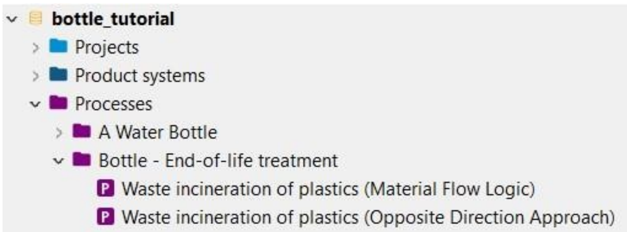


Figure 47: End-of-Life treatment processes used in the Bottle Tutorial

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.

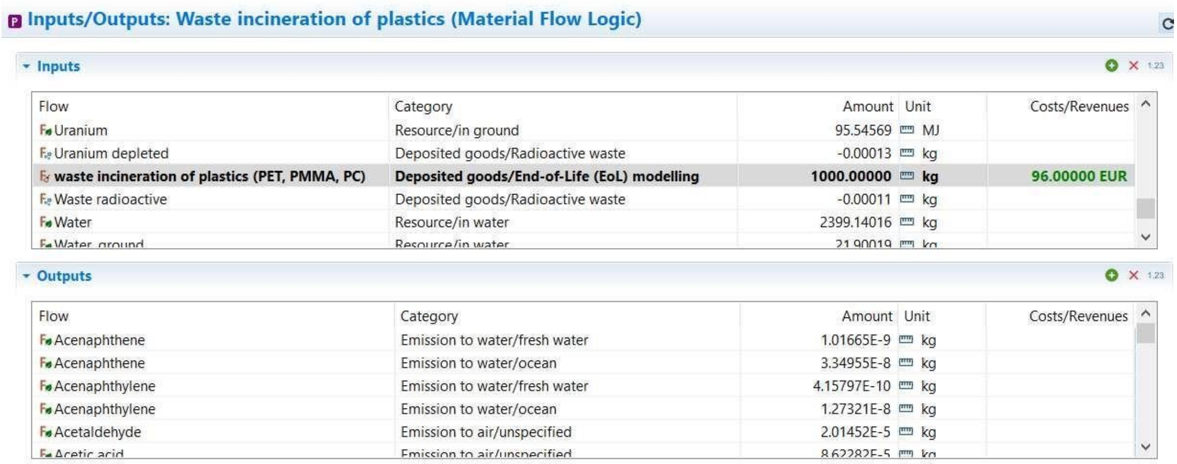


Figure 48: Inputs/Outputs tab of the process *Waste incineration of plastics (Material Flow Logic)*

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)*.

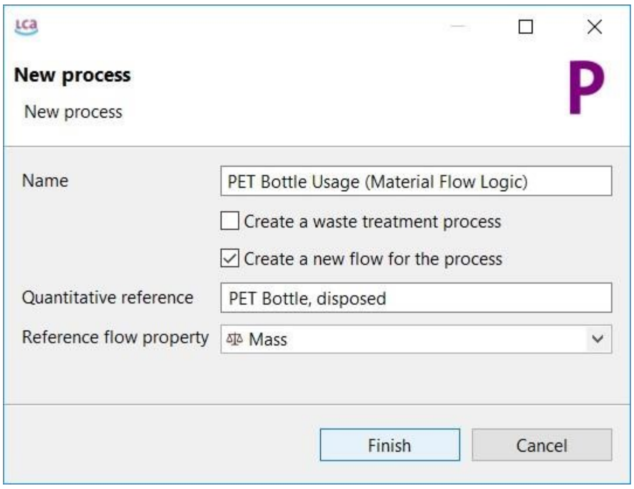


Figure 49: Create a new process *PET Bottle Usage (Material Flow Logic)*

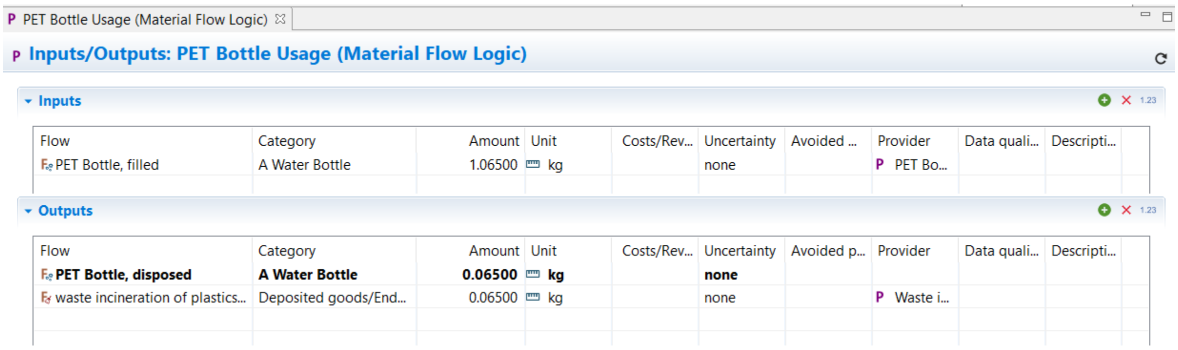


Figure 50: Inputs/Outputs tab of the process *PET Bottle Usage (Material Flow Logic)*

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.

Flow	Category	Amount	Unit	Costs/Revenues
Aggregate, natural	Resource/in ground	0.12579	kg	
Air	Resource/in air	1.34460E4	kg	
Barite	Resource/in ground	1.01705E-12	kg	
Barite	Resource/in ground	0.03524	kg	
Basalt, in ground	Resource/in ground	0.00737	kg	
Bauxite	Resource/in ground	9.92536E-5	kg	

Flow	Category	Amount	Unit	Costs/Revenues
VOC, volatile organic compounds, unspecified origin	Emission to water/fresh water	4.92955E-7	kg	
VOC, volatile organic compounds, unspecified origin	Emission to water/ocean	2.64949E-8	kg	
waste incineration of plastics (PET, PMMA, PC)	**End-of-life treatment/Energy recycling**	**-1000.00000**	**kg**	**96.00000 EUR**
Water vapour	Emission to air/unspecified	42.74772	kg	
Xenon-131m	Emission to air/unspecified	0.00612	kBq	
Xenon-133	Emission to air/unspecified	1.00129	kBq	

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)*.

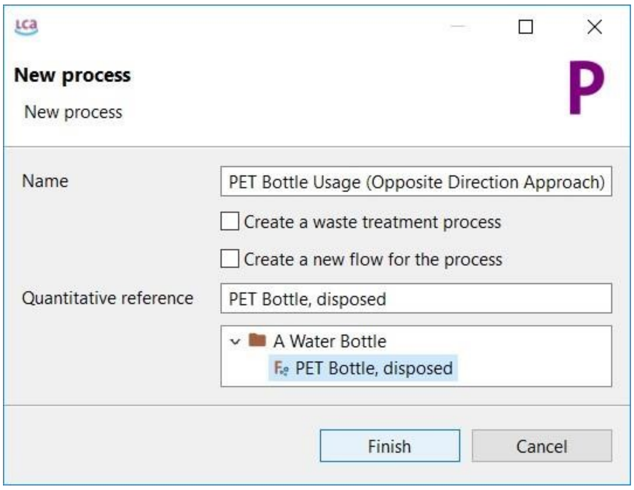
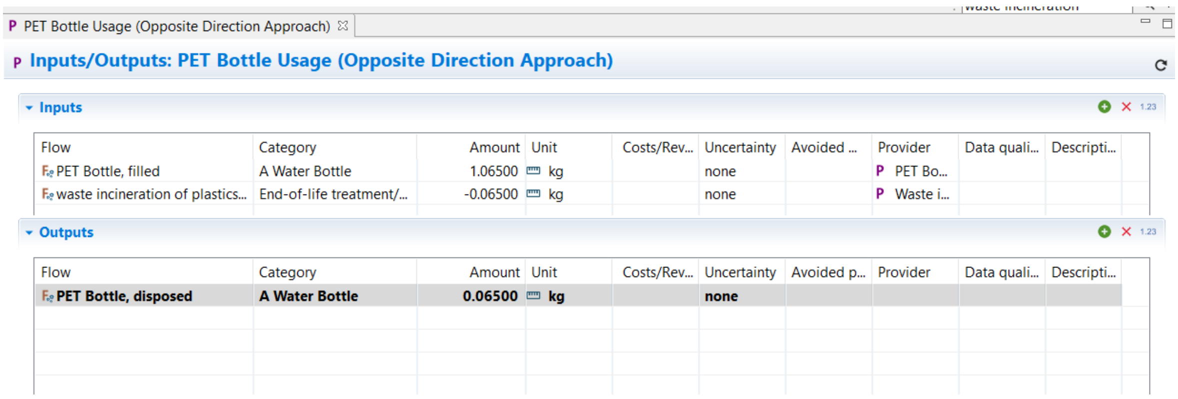


Figure 52: Create a new process *PET Bottle Usage (Opposite Direction Approach)*



Flow	Category	Amount	Unit	Costs/Rev...	Uncertainty	Avoided ...	Provider	Data quali...	Descripti...
PET Bottle, filled	A Water Bottle	1.06500	kg		none		PET Bo...		
waste incineration of plastics...	End-of-life treatment/...	-0.06500	kg		none		Waste i...		

Flow	Category	Amount	Unit	Costs/Rev...	Uncertainty	Avoided p...	Provider	Data quali...	Descripti...
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.

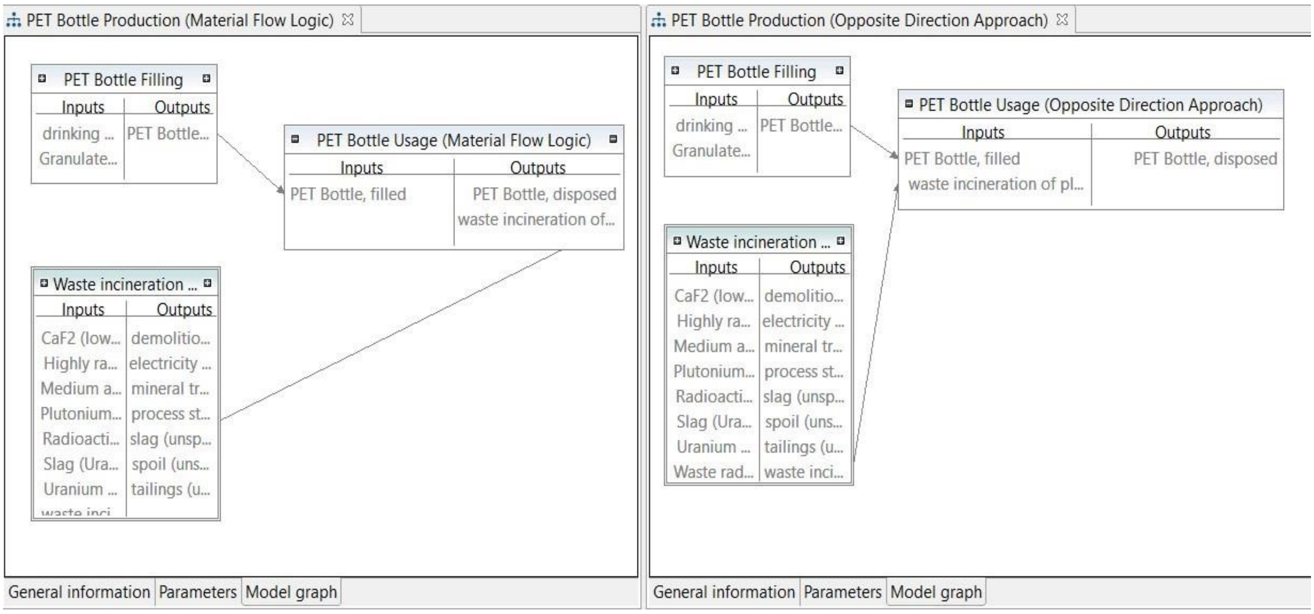


Figure 54: Model graphs of the product systems *PET Bottle Production (Material Flow Logic)* and *PET Bottle Production (Opposite Direction Approach)*

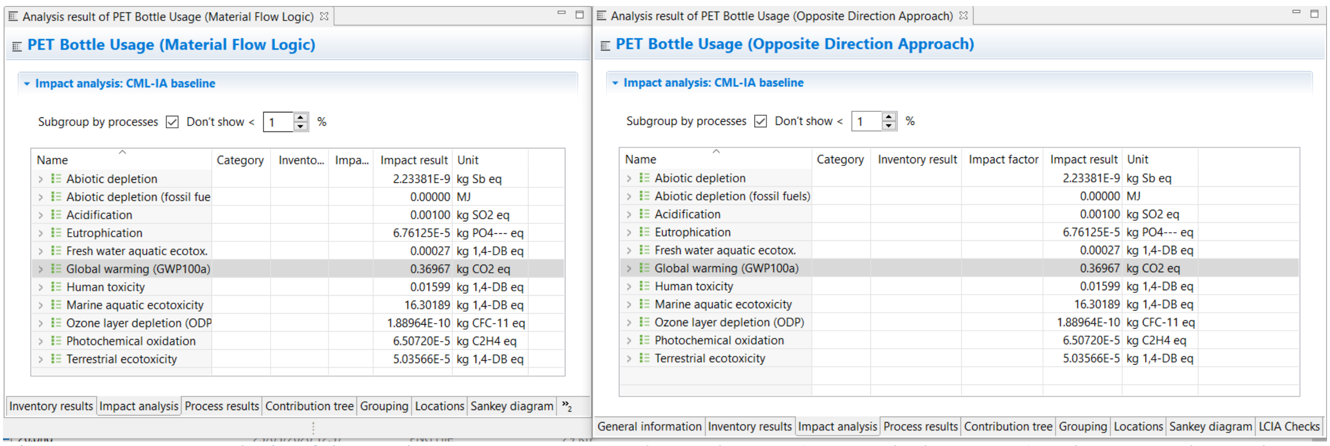


Figure 55: Impact analysis of the product systems *PET Bottle Production (Material Flow Logic)* and *PET Bottle Production (Opposite Direction Approach)*

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.

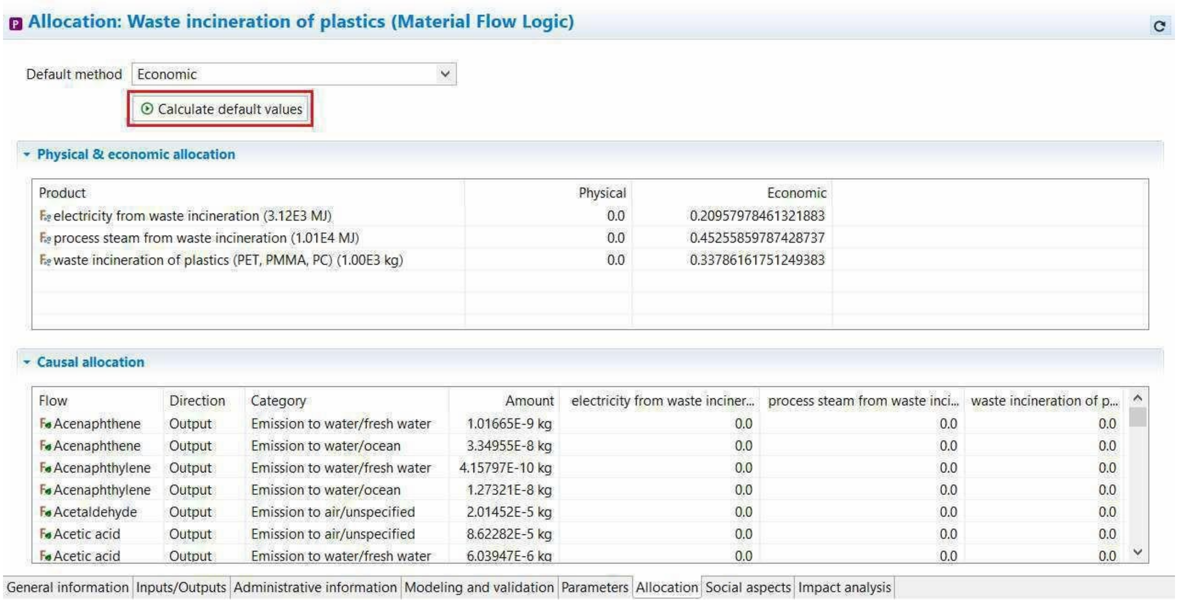


Figure 56: Allocation tab of the process *Waste incineration of plastics (Material Flow Logic)*

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.

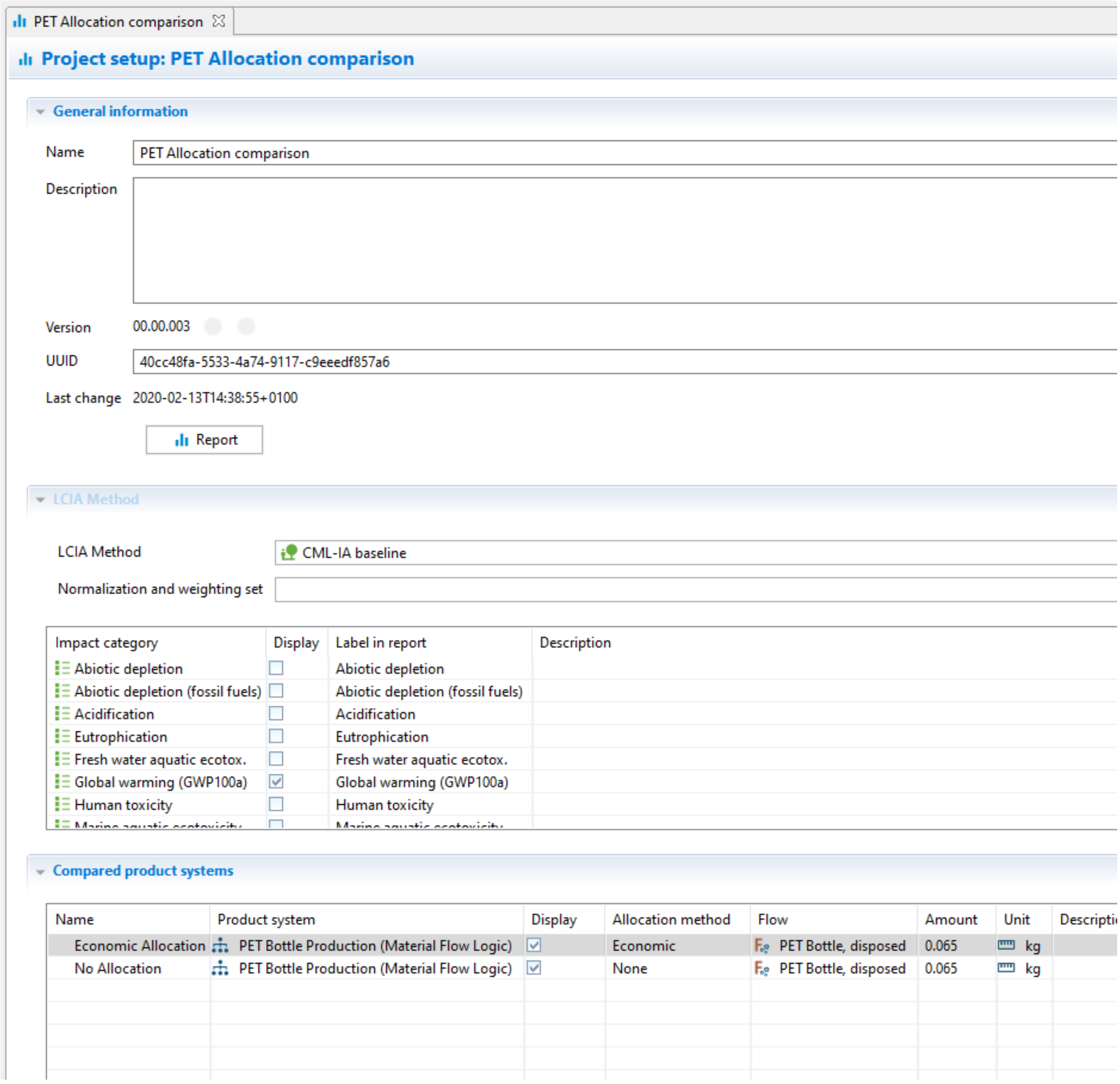


Figure 57: Project setup of the project *PET Allocation comparison*

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.

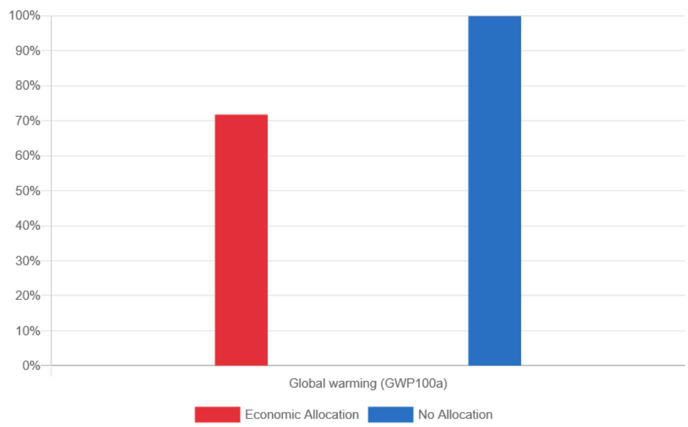


Figure 58: Relative results of the project *PET Allocation comparison*

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 *open*
Copy and paste	Right-click on the element to be duplicated and select *copy*, right-click on the folder or the Input/Output table, in which the copied element should be saved, and select *paste*
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 *Windows* in the main menu and select *Show views* and *Other* 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.

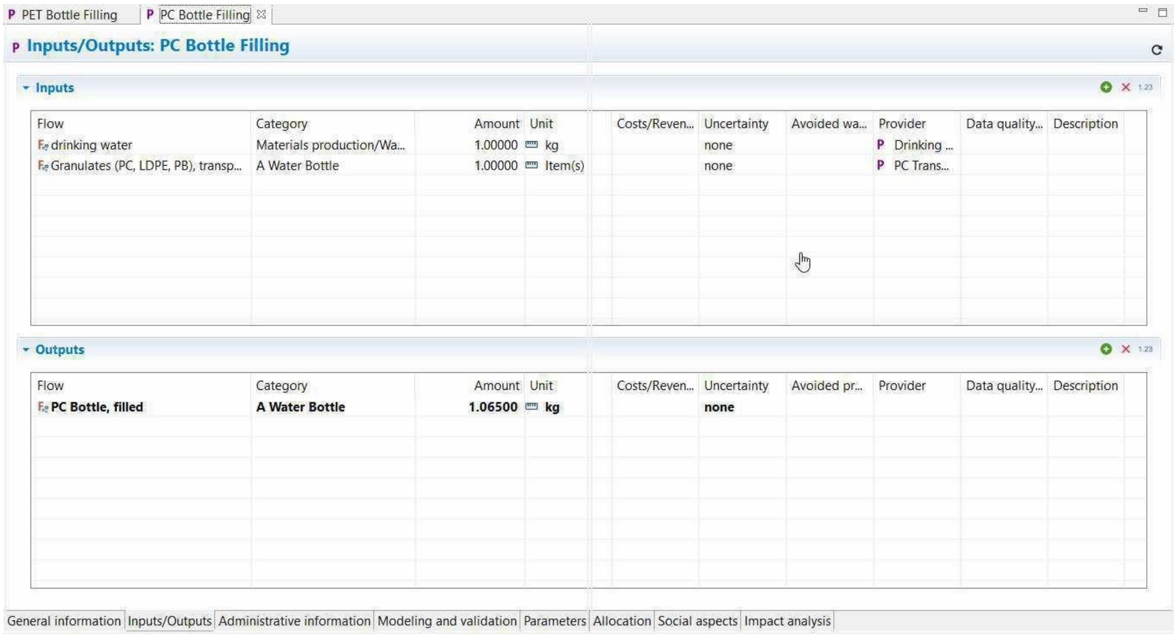


Figure 59: Drag and drop window to open split view

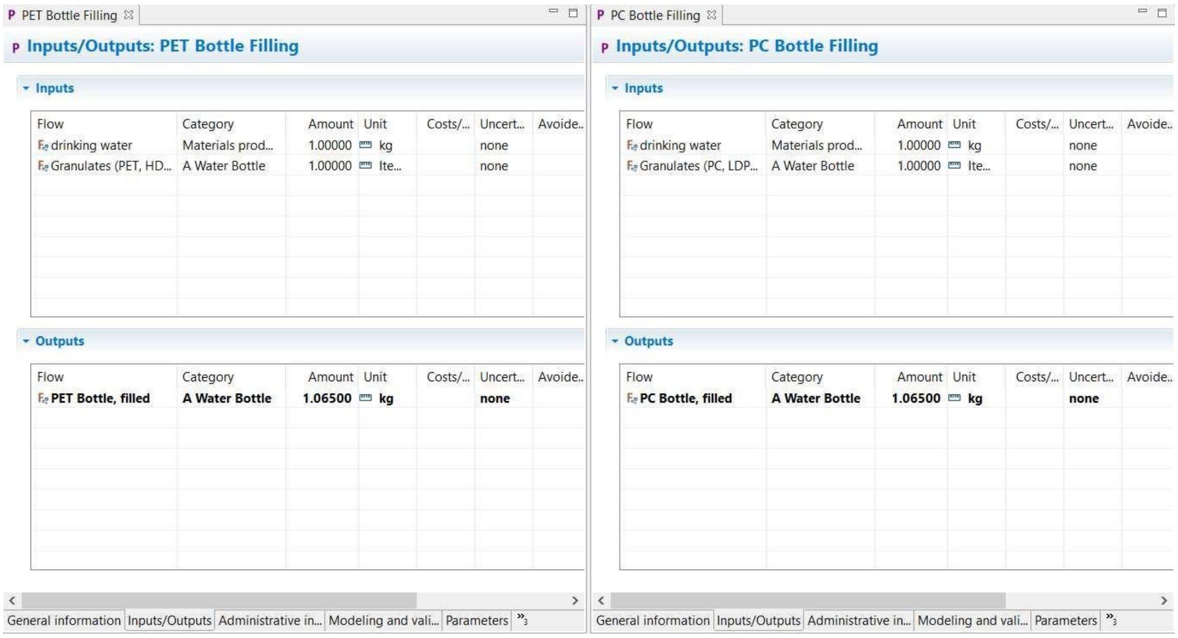


Figure 60: Windows opened in split view

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

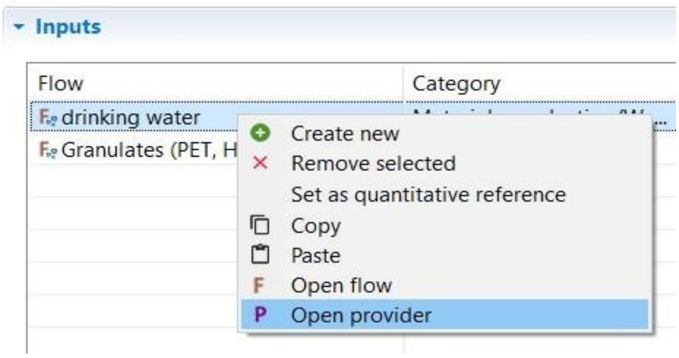


Figure 61: Open provider of a flow

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.

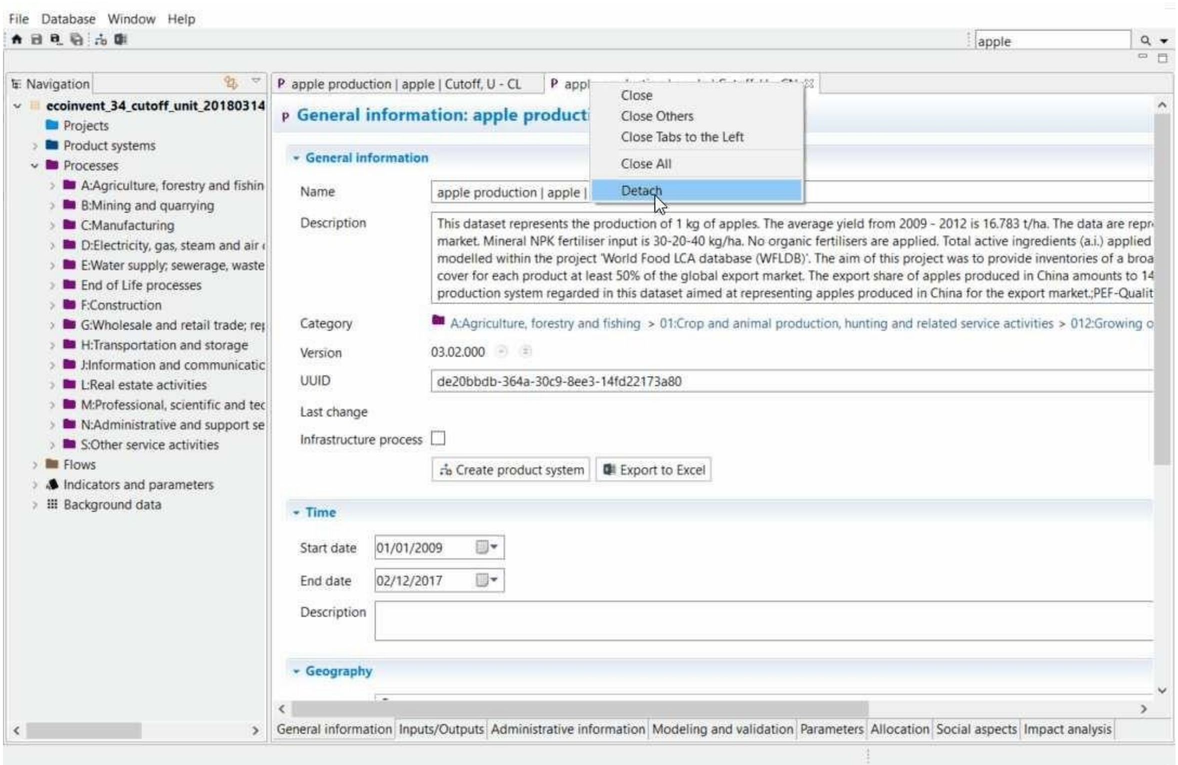


Figure 62: Detach a window

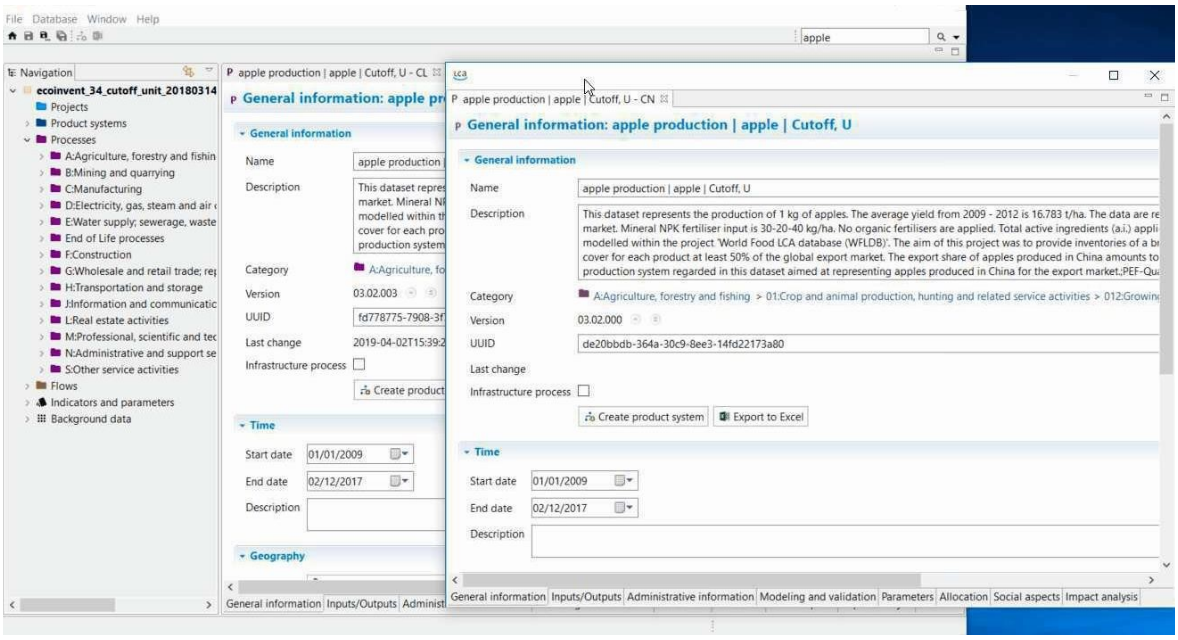


Figure 63: Detached windows

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.

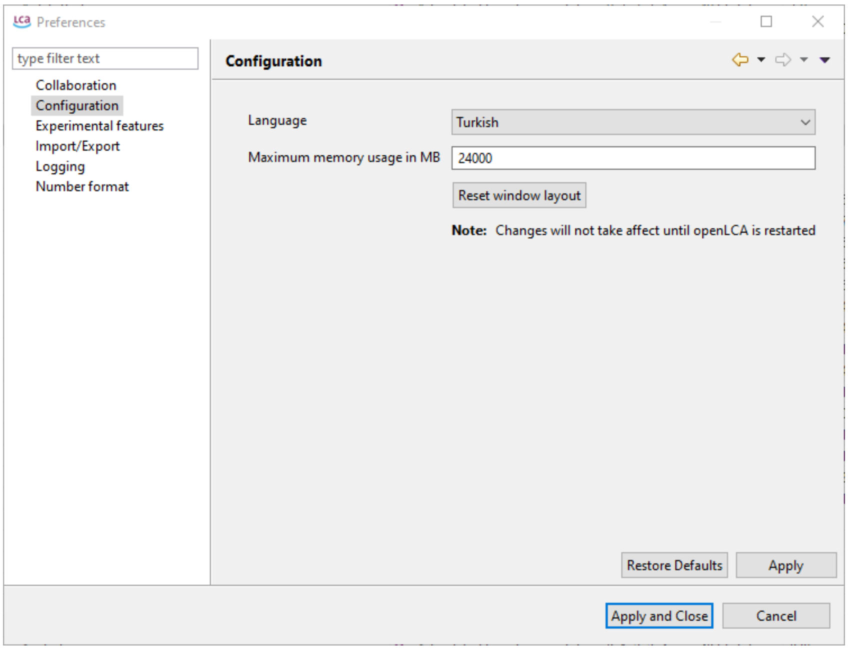


Figure 64: Language and memory usage configuration

12 openLCA and LCA support

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

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