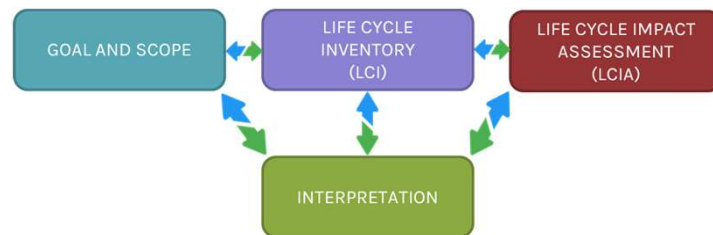




## Life Cycle Assessment (LCA)

Life Cycle Assessment is a technique for assessing the environmental (or social) **impacts** that occur during **all stages** of a product's life cycle (from cradle-to-grave)



3

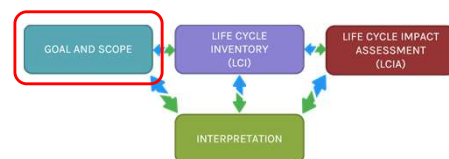
## Goal and Scope

### Goal of the study

- ◆ Context of the study
- ◆ Aim of the evaluation
- ◆ Intended audience

### Scope of the study

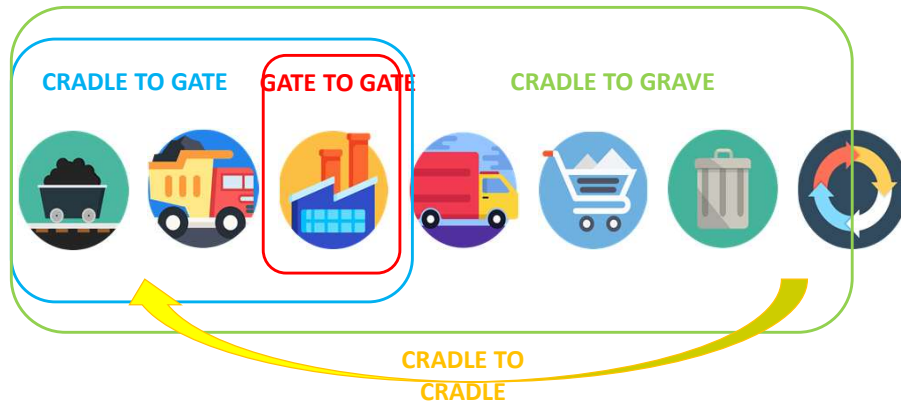
- ◆ Functional Unit
- ◆ System Boundary
- ◆ Data quality
- ◆ Limitations and assumptions
- ◆ Allocation (Phys, Eco)
- ◆ Impact Categories



UNI EN ISO 14044:2006  
International Reference Life Cycle Data System (ILCD) Handbook

4

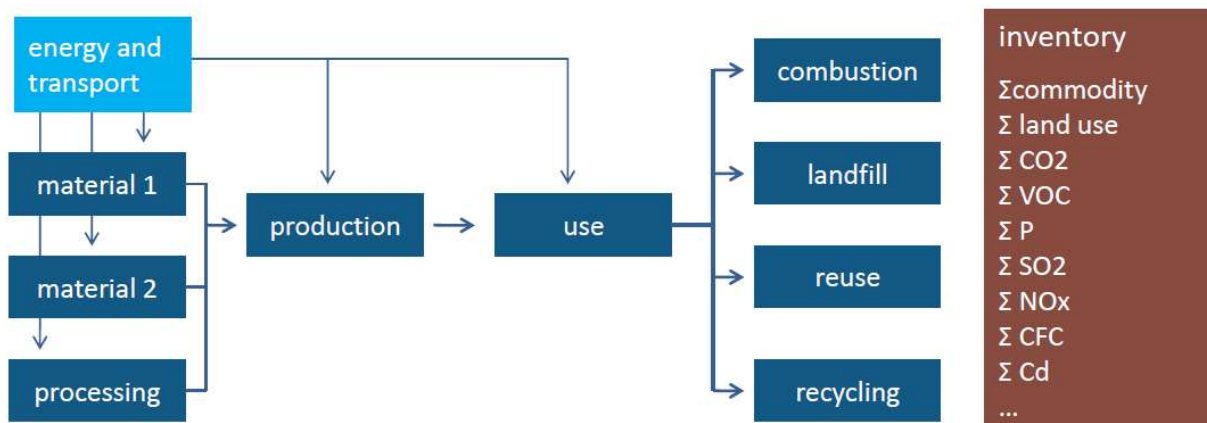
## System boundary



UNI EN ISO 14040-44  
International Reference Life Cycle Data System (ILCD) Handbook

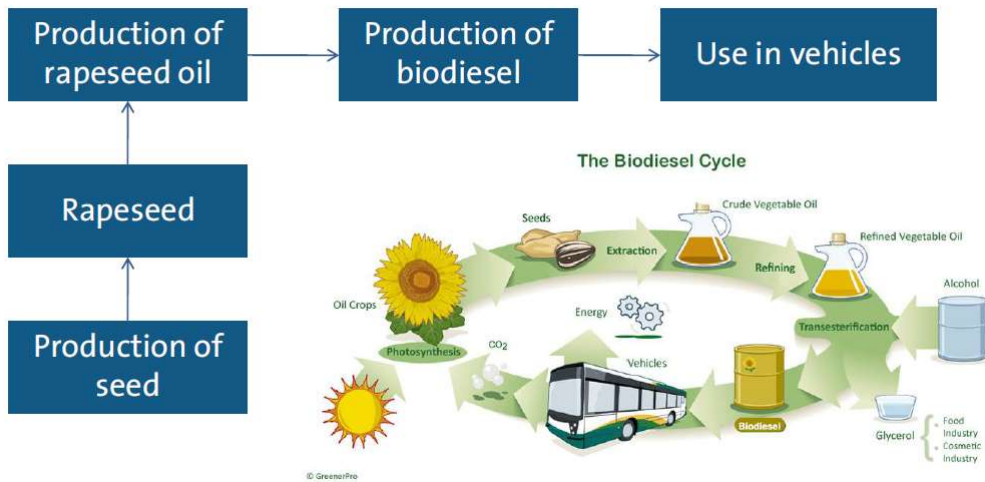
5

## Determining the flow diagram



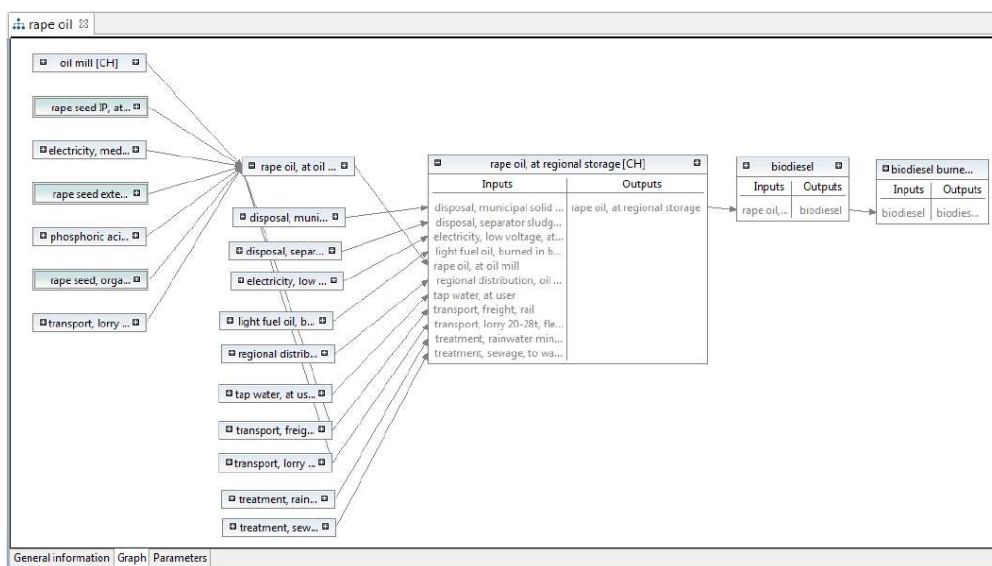
6

## Flow diagram example: rapeseed oil as biodiesel



7

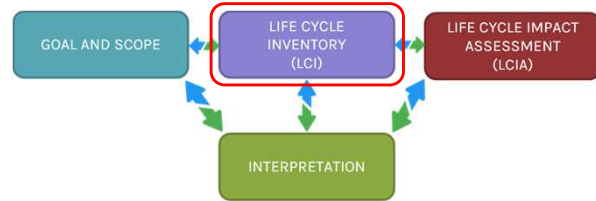
## Process network for rapeseed oil-based biodiesel



8

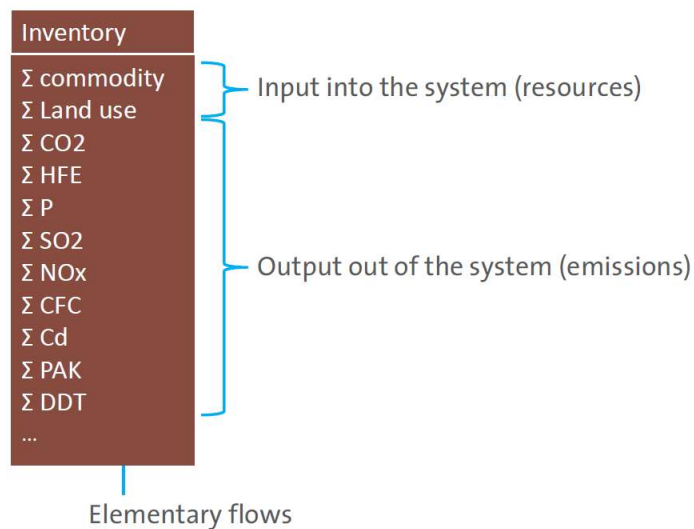
## Life Cycle Inventory (LCI)

- ◆ Data collection (suppliers, survey, literature, database, reverse engineering, primary data)
- ◆ Determining input (resources) and output (product, byproducts, waste, emissions) flows in terms of materials
- ◆ If necessary, adjustment of the goal and scope
- ◆ Creation of the flow diagram of the product life-cycle



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## Life Cycle Inventory (LCI)



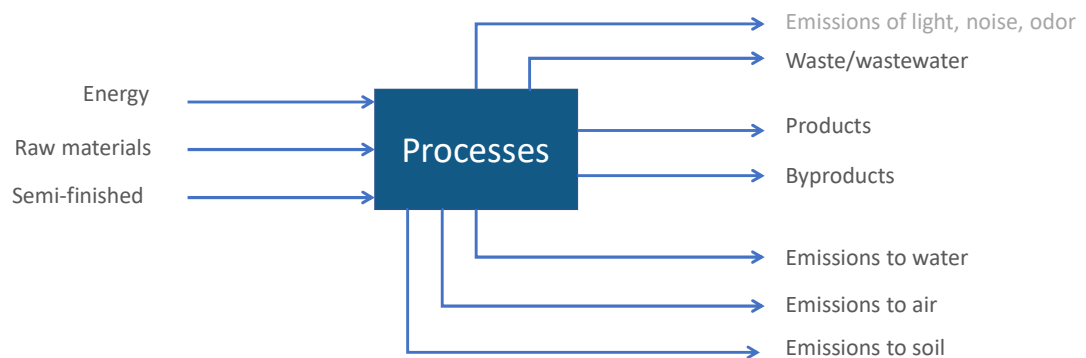
10

## Calculated Inventory

Inventory results				
Inputs				
Flow	Category	Sub-category	Unit	Amount
Clay, bentonite, in ground	resource	in ground	kg	0.00010
Transformation, to permanent crop, fruit, intensive	resource	land	m2	1.36330E-8
Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground	resource	in ground	kg	2.24214E-8
Gold, Au 4.3E-4%, in ore, in ground	resource	in ground	kg	2.00562E-10
Occupation, tropical rain forest	resource	land	m2*a	0.00076
Transformation, from unknown	resource	land	m2	2.16097E-5
Occupation, traffic area, road embankment	resource	land	m2*a	0.00043
Calcium carbonate, in ground	resource	in ground	kg	0.01250
Outputs				
Flow	Category	Sub-category	Unit	Amount
Carbon dioxide, fossil	air	unspecified	kg	0.02676
Benzene	water	surface water	kg	2.25865E-6
Chromium, ion	water	ocean	kg	4.27239E-9
Dimethylamine	water	surface water	kg	2.65300E-8
Cumene	air	unspecified	kg	5.35044E-17
Antimony	water	surface water	kg	2.65496E-8
Protactinium-234	water	surface water	kBq	4.37261E-6
Methyl acrylate	air	high population density	kg	2.21688E-12

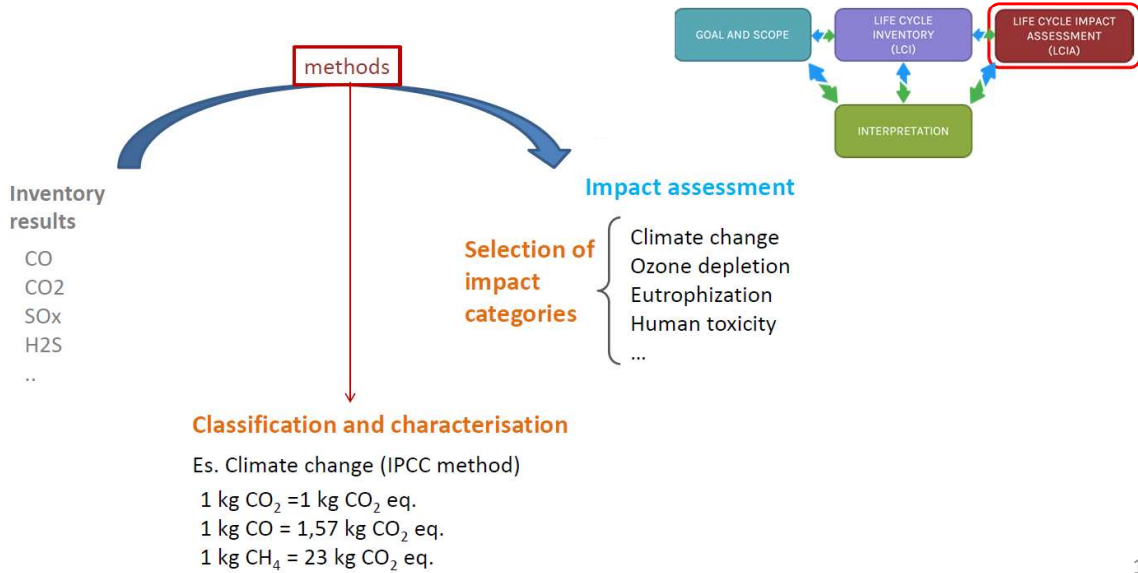
11

## Data types



12

# Life Cycle Impact Assessment (LCIA)



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# Steps of LCIA

**Impact factors: ILCD 2011, midpoint [v1.0.10, August 2016]**

Impact category: Climate change

Flow	Category	Flow proj	Factor	Unit
Butane, perfluoro-	Emission to air/low population densi...	Mass	8860.0	kg CO2 eq./kg
Butane, perfluoro-	Emission to air/lower stratosphere +...	Mass	8860.0	kg CO2 eq./kg
Butane, perfluoro-	Emission to air/unspecified	Mass	8860.0	kg CO2 eq./kg
Butane, perfluorocyclo-, PFC-318	Emission to air/high population density	Mass	10300.0	kg CO2 eq./kg
Butane, perfluorocyclo-, PFC-318	Emission to air/low population density	Mass	10300.0	kg CO2 eq./kg
Butane, perfluorocyclo-, PFC-318	Emission to air/high population densi...	Mass	10300.0	kg CO2 eq./kg
Butane, perfluorocyclo-, PFC-318	Emission to air/lower stratosphere +...	Mass	10300.0	kg CO2 eq./kg
Butane, perfluorocyclo-, PFC-318	Emission to air/unspecified	Mass	10300.0	kg CO2 eq./kg
Carbon dioxide	Emission to air/high population density	Mass	1.0	kg CO2 eq./kg
Carbon dioxide	Emission to air/low population density	Mass	1.0	kg CO2 eq./kg

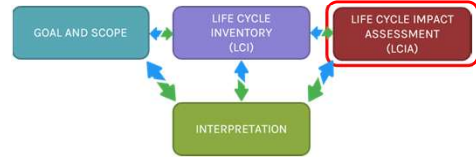
↓ **Classification**      ↓ **Characterisation**

**GOAL AND SCOPE** ↔ **LIFE CYCLE INVENTORY (LCI)** ↔ **LIFE CYCLE IMPACT ASSESSMENT (LCIA)**

**INTERPRETATION** (between LCI and LCIA)

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## Steps of LCIA



### Characterisation - Example

$$\text{Climate change} = \sum GWP_i \cdot mass_i$$

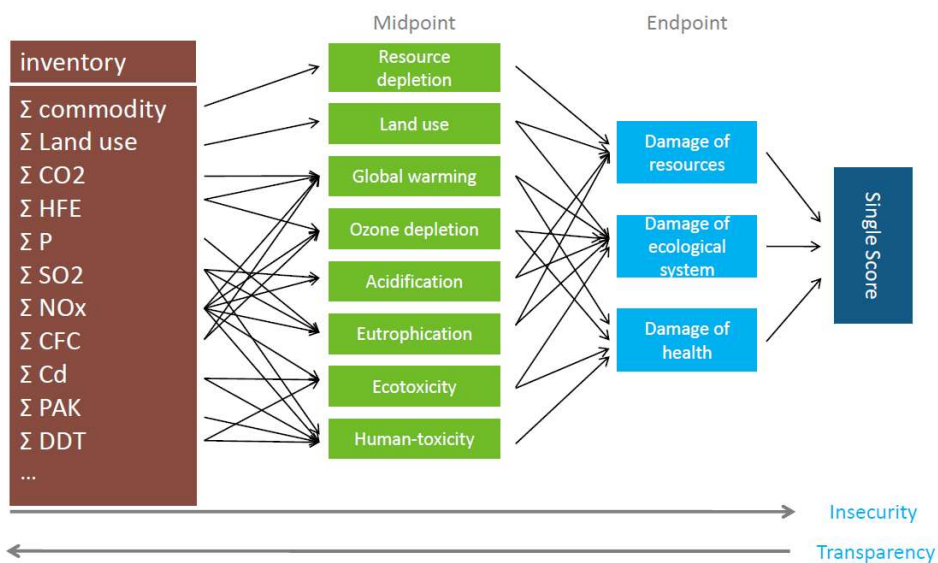
Air emissions per 1 kWh of Electricity Mix (IT)

Flow	Factor (IPPC 2007)	Quantity [g]
Carbon dioxide (CO <sub>2</sub> )	1	1.55
Methane (CH <sub>4</sub> )	25	0.0033
Dinitrogen monoxide (N <sub>2</sub> O)	298	2.38 E-5
Flow <sub>i</sub>	GWP <sub>i</sub>	mass <sub>i</sub>

ILCD 2011, midpoint [v1.0.10, August 2016];  
Climate change - IPCC 2007; GWP100 - Reference unit: kg CO<sub>2</sub> eq.

GWP of 1 kWh of Electricity Mix (IT) =  
 $= (1 * 1.55) \text{ g} + (25 * 0.0033) + (298 * 2.38\text{E-}5) + \sum GWP_i \cdot mass_i$

## Steps of LCIA





## Steps of LCIA

According to ISO 14040-44

- **Selection of impact categories**
  - **Classification**
  - **Characterization**
  - **Normalization**
  - **Grouping**
  - **Weighting**
- } mandatory
- } optional

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## Steps of LCIA

### Normalization

Calculation of the **magnitude** of category indicator results relative to reference information. Consists in **dividing values of category indicators by a reference measure**.

Example:

JRC EU 27, 2010, total [year]

JRC EU 27, 2010, per person [person/year]



Normalization	
Impact category	Amount
Resource depletion - water	8.94635
Human toxicity - carcinogenics	7.16312
Human toxicity - non-carcinogenics	4.18130
Land use	3.23476
Marine eutrophication	1.54674
Photochemical ozone formation	1.18695
Freshwater ecotoxicity	1.08884
Terrestrial eutrophication	0.86622
Acidification	0.72633
Resource depletion - mineral, fossils and rene...	0.62606
Particulate matter/Respiratory inorganics	0.38932
Freshwater eutrophication	0.25511
Ionizing radiation - human health	0.16675
Ozone depletion	0.04809
Ionizing radiation - ecosystems	0.00000
Nuova categoria di impatto	0.00000
Nuova categoria di impatto	0.00000
Climate change	-5.31630

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## Steps of LCIA

### Grouping and weighting

In weighting, the (typically normalised) indicator results for the different impact categories or damages are each multiplied by a **specific weighting factor**, that is intended to **reflect the relative relevance** of the different impact categories / category endpoints among each other.

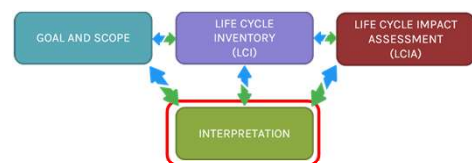


It becomes possible to add up indicators and obtain a single score indicator!

*...there is much less consensus among the scientific community!*

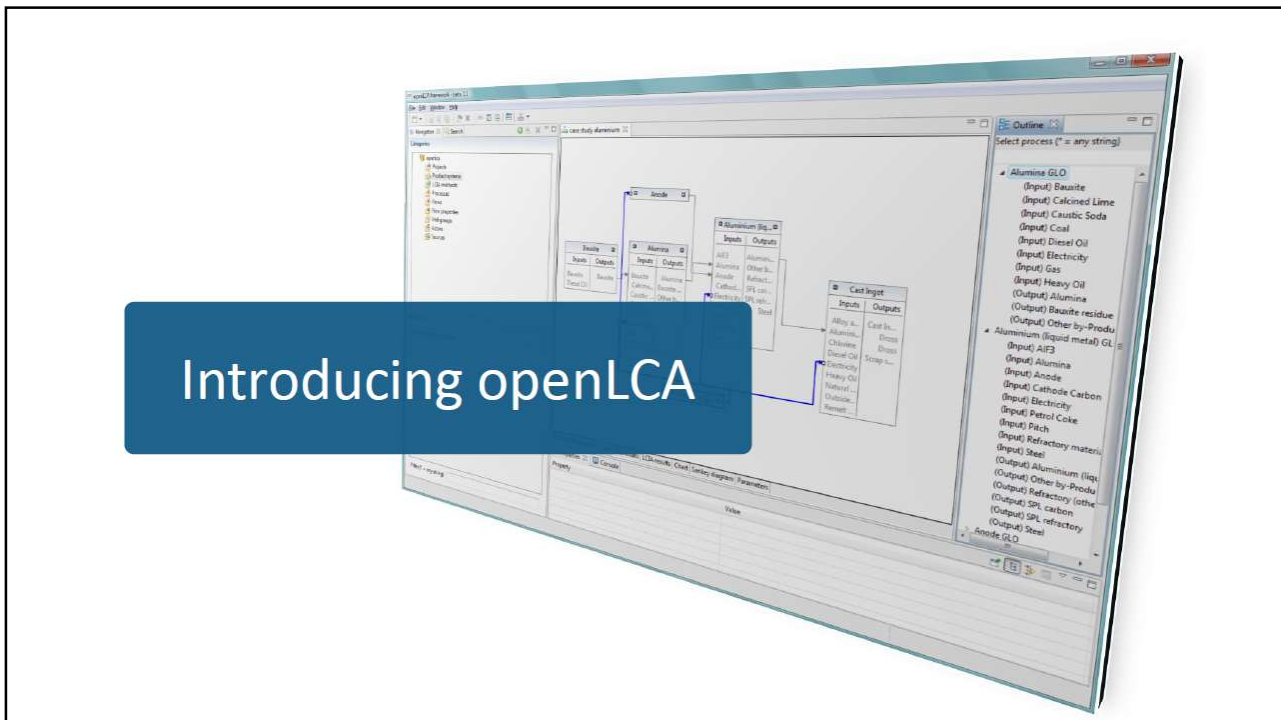
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## Interpretation



- ◆ Identification of significant issues
- ◆ Based on the LCI and LCIA results
- ◆ Sensitivity analysis
- ◆ Completeness and consistency checks
- ◆ Conclusions / Limitations / Recommendations

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## openLCA

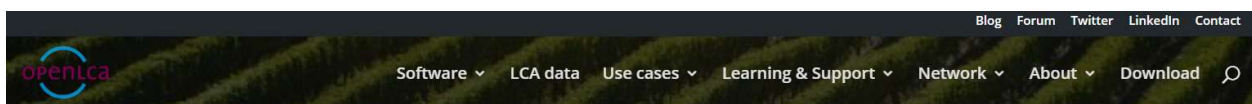
- ◆ A free and (yet) professional approach to Life Cycle Assessment: powerful, feature rich, (comparatively) easy to use, technically up to date
- ◆ developed by GreenDelta since 2006
- ◆ completely Open Source (Mozilla Public License)
- ◆ Native to Windows, Mac OS and Linux
- ◆ Established and growing community of users: more than 10k downloads/yr
- ◆ Broadest selection of relevant, consistent LCI and sustainability databases available worldwide

## openLCA application

- ◆ Life Cycle Assessment, Life Cycle Costing, Social Life Cycle Assessment
- ◆ Carbon and Water footprint
- ◆ Product Environmental Footprint (PEF)
- ◆ Environmental Product Declarations (EPD)
- ◆ US Environmental Protection Agency (EPA)'s Design for Environmental Label
- ◆ Integrated Product Policy

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## openLCA.org



- ◆ Downloads (software, LCIA methods, ...)
- ◆ Videos, manuals, case studies
- ◆ Services (service contracts, training, critical reviews, hosting & data management solutions, ...)
- ◆ Forum & Blog

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# openLCA.org/downloads

## Downloads



### openLCA

Here's presenting the latest version 1.10.3 (release date: June 24th, 2020). We recommend using this version. Our tests have not shown any issues, but should you run into any, please let us know. Thanks in advance!

Windows	Mac	Linux	Sources	Latest build
---------	-----	-------	---------	--------------

To use openLCA in windows, download the zip-archive below: Just unzip the archive and start openLCA.exe. To uninstall it, just delete the created folder. You can have several versions of openLCA in different folders on the same computer.

openLCA 1.10.3 zip-archive: [openLCA\\_win64\\_1.10.3\\_2020-06-24.zip](#)

Alternatively, you can install openLCA with the installer below. If you have an older openLCA version installed (via the installer) you should uninstall it first.

openLCA 1.10.3 installer: [openLCA\\_win64\\_1.10.3\\_2020-06-24](#)

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# openLCA.org/downloads



### Impact methods

Several impact methods for use in openLCA are available. The methods are provided for free, as openLCA databases, which can be easily imported into openLCA. If you have any comments or would like to submit own methods, please [let us know](#).

General purpose	Social LCA	EPD creation	ecoinvent	AWARE
-----------------	------------	--------------	-----------	-------

A comprehensive package of environmental impact assessment methods for use with all different databases available in the nexus system – including ecoinvent 3, GaBi and ELCD is available here. It includes normalisation and weighting as far as this is foreseen by the method. Please observe the license\* (Commons Attribution-ShareAlike 4.0 International) while using it. Please [provide feedback](#) – thanks in advance!

Note that **newer openLCA LCIA methods**, especially the comprehensive 2.0 package for “countrified” databases [released April 2018](#), are available on openLCA Nexus from now on only, here: <https://nexus.openlca.org/database/openLCA%20LCIA%20methods>.

[openLCA LCIA method pack 1.5.7](#) as openLCA database for openLCA 1.6 (and also 1.7), last update: October 22nd, 2017. The newest methods are also available on the [Nexus website](#).

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# openLCA.org/learning

## Free resources

To help you get started with openLCA, we are providing many free resources, from manuals on the software to handbooks on specific topics, to guidance on impacts assessment methods and some ready to use case studies to get inspiration on modeling your own LCA study.



### Manuals and presentations

Sometimes it is good to have a more comprehensive text which explains details – this section contains some manuals for different openLCA versions and related, typically more specific, topics. Also the format converter documentation is available.

openLCA, general	Specific topics	Databases	Presentations	Format converter
Version 1.10.2				
<ul style="list-style-type: none"> <li>• <b>New! Comprehensive openLCA manual for version 1.10, February 2020</b></li> </ul>				

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# Ask.openLCA

ask.openLCA
Questions   Unanswered   Tags   **Ask a Question**

**Recent questions and answers** 📡

+1  
vote

1

answer

**Adding flows to ecoinvent 3.6 (Python Addon)**

answered **1 hour** ago in openLCA by laurent.bocahut (240 points)

python   flows   add   path

0  
votes

0  
answers

**I cannot import the lciadatabase into other database**

asked **16 hours** ago in openLCA by HildeHennyWjngaard (120 points)

database   import   openlca   life cycle impact assessment (lca)

0  
votes

1

answer

**Data quality properties**

answered **17 hours** ago in openLCA by Andreas Ciroth (64k points)

data quality   ecoinvent   pedigree scores   pedigree matrix

0  
votes

0  
answers

**Error on Flow Mapping when applying on database**

asked **18 hours** ago in openLCA by sekunde (120 points)

flows   mapping   database   openlca   apply on database

+1  
vote

1

answer

**Error: missing parameter in formula**

answered **1 day** ago in openLCA by Matias Lund (140 points)

parameter   validation   openlca

0  
votes

0  
answers

**openLCA 1.10.3 cannot be started from shared folder**

asked **1 day** ago in openLCA by phiweb (120 points)

ask.openLCA is a question-and-answer (Q&A) website on **Life Cycle Assessment (LCA)**.

It is also the public support platform for **openLCA**, **openLCA Nexus**, **data.openLCA** and the **LCA Collaboration Server**.

Receive guaranteed and prioritised professional support via **GreenDelta's help desk**.

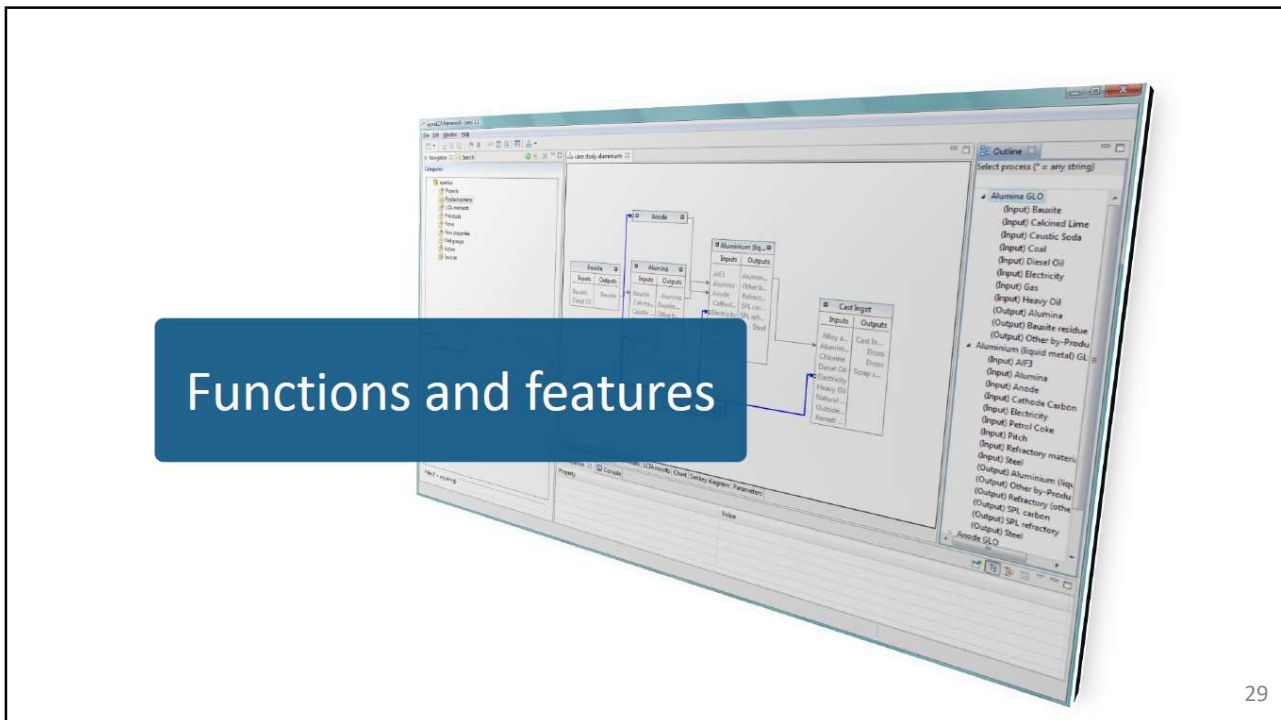
ask.openLCA is run by **GreenDelta**, the creators of openLCA.

**Categories**

All categories

openLCA	(1-14)
Miscellaneous	(53)
LCA Collaboration Server	(33)

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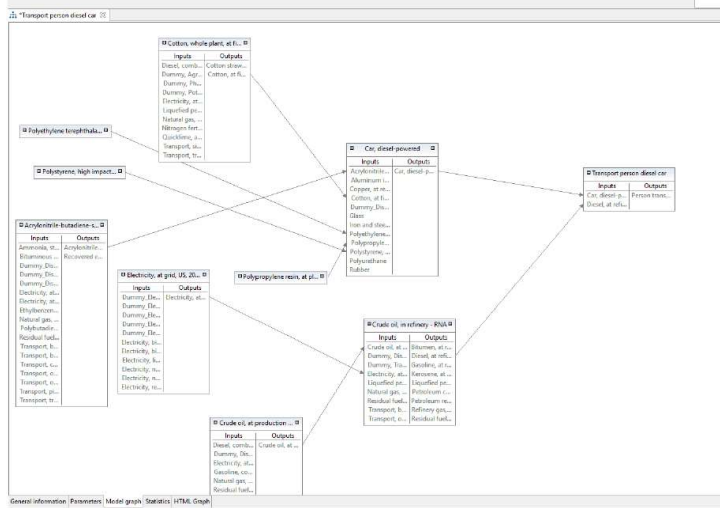
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## Graphical modeling of product systems

- ◆ Product system = Process networks
- ◆ Process networks can be created automatically and manually
- ◆ Graphical modeling based on the Eclipse Graphical Editing Framework (GEF)
- ◆ Different product systems can be compared using the “Projects” feature

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# Graphical modeling of product system based on Eclipse GEF



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# Allocation and system expansion for modeling multi-output processes

Ethanol, denatured, corn dry mill - RNA

Allocation

Default method: Causal

Calculate default values

Physical & economic allocation

Product	Physical	Economic
For RNA: Ethanol, denatured, corn dry mill (...)	1.0	1.0
For RNA: distillers dried grains with solubles...	0.01	0.01

Causal allocation

Flow	Direction	Category	Amount	RNA: dis...	RNA: Eth...
For RNA: corn grain, harveste...	Input	US LCI Dat...	0.95302 kg	0.01	1.0
For RNA: dummy yeast past...	Input	US LCI Dat...	0.00403 kg	0.01	1.0
For Water vapour	Output	air/unspeci...	4.31052 kg	0.01	1.0
For RNA: com wet milling op...	Input	US LCI Dat...	0.99933 kg	0.01	1.0
For Water, ground	Input	resource/in...	4.81121 kg	0.01	1.0
For RNA: Nitrogen fertilizer, ...	Input	US LCI Dat...	0.01445 kg	0.01	1.0
For Methane	Output	air/unspeci...	-0.00340 kg	0.01	1.0
For RNA: Electricity, at grid, ...	Input	US LCI Dat...	1.33494 MJ	0.01	1.0
For RNA: corn grain, at conv...	Input	US LCI Dat...	3.11409 kg	0.01	1.0
For Gasoline (regular)	Input	Crude oil p...	0.01312 kg	0.01	1.0

General information | Inputs/Outputs | Administrative information | Modeling and validation | Parameters | Allocation | Social aspects

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## Modeling with parameters

- ◆ Parameters can be used instead of concrete values for inputs/outputs
- ◆ Defined as simple value, formula or complex function
- ◆ Parameters can overwrite each other
- ◆ Available on different levels
  - ◆ process
  - ◆ product system
  - ◆ project
  - ◆ impact method
  - ◆ database

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## Local and global parameters

The screenshot shows a software interface for parameter management. The main window is titled 'Parameters' and is divided into several sections:

- Global parameters:** A table with columns for Name, Value, Uncertainty, and Description. It lists various parameters such as Benzene\_h, bucket\_volume, CH4\_h, CO2\_h, cycles\_min, density, Dust\_h, fuel\_h, load\_factor, N2O\_h, NMVOC\_h, NOx\_h, sulphur\_ppm, Toluene\_h, and Xylene\_h.
- Input parameters:** A table with columns for Name, Value, Uncertainty, and Description. It lists parameters like Benzene\_h, bucket\_volume, CH4\_h, CO2\_h, cycles\_min, density, Dust\_h, fuel\_h, load\_factor, N2O\_h, NMVOC\_h, NOx\_h, sulphur\_ppm, Toluene\_h, and Xylene\_h.
- Dependent parameters:** A table with columns for Name, Formula, Value, and Description. It lists parameters like Benzene\_t, CH4\_t, CO2\_t, Dust\_t, and fuel\_t, each with a corresponding formula and value.

The 'Global parameters' table is highlighted with a red box. The 'Input parameters' table is also highlighted with a red box. The 'Dependent parameters' table is highlighted with a red box. The sidebar on the right shows a tree view with 'Global parameters' and 'Parameter1' highlighted with a red box.

Name	Value	Uncertainty	Description
Benzene_h	0.021	none	[13] [g Benzene/h] at full L...
bucket_volume	1.1	none	[02a] [m3] bucket volume
CH4_h	0.72	none	[11] [g CH4/h] at full load
CO2_h	150.0	none	[07] [g CO2/h] at full load
cycles_min	0.75	none	[02b] [1/min] number of c...
density	1.8	none	[01] [t/m3] density of exca...
Dust_h	15.0	none	[09] [g Dust/h] at full load
fuel_h	25.5	none	[05] [kg fuel/h] at full load
load_factor	0.6	none	[04] [-] effective power in ...
N2O_h	3.0	none	[10] [g N2O/h] at full load
NMVOC_h	29.0	none	[12] [g NMVOC/h] at full L...
NOx_h	520.0	none	[08] [g NOx/h] at full load
sulphur_ppm	200.0	none	[03] [ppm] sulphur conten...
Toluene_h	0.003	none	[14] [g Toluene/h] at full L...
Xylene_h	0.264	none	[15] [g Xylene/h] at full lo...

Name	Formula	Value	Description
Benzene_t	Benzene_h*load_factor/performance*den...	4.581818181818181E-4	[24] [g Benzene/t]
CH4_t	CH4_h*load_factor/performance*density	0.01570909090909091	[22] [g CH4/t]
CO2_t	CO2_h*load_factor/performance*density	3.2727272727272725	[18] [g CO2/t]
Dust_t	Dust_h*load_factor/performance*density	0.3490909090909091	[20] [g Dust/t]
fuel_t	fuel_h*load_factor/performance*density	0.5555555555555556	[16] [kg fuel/t]

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## Inventory Calculation

- ◆ Calculation of life cycle inventory (using the “matrix method”)
- ◆ Results are clearly presented in two tables (inputs/outputs)
- ◆ Result can be exported to Excel

```

> A
Diesel prod. Bauxite mining Alumina prod. Anode prod. Electrolysis Ingot casting
Diesel [kg] 1 -1.993 -0.6 -3.2 0 -0.1
Bauxite, at plant [kg] 0 1000.000 -2685.0 0.0 0 0.0
Alumina [kg] 0 0.000 1000.0 0.0 -1925 0.0
Anode [kg] 0 0.000 0.0 1000.0 -441 0.0
Aluminium (liquid metal) [kg] 0 0.000 0.0 0.0 1000 -874.0
Ingot [kg] 0 0.000 0.0 0.0 0 1000.0
> B
Diesel prod. Bauxite mining Alumina prod. Anode prod. Electrolysis Ingot casting
Crude oil [kg] -1.500000 0 0.00 0.00 0.00 0.00
Bauxite [kg] 0.000000 -1000 0.00 0.00 0.00 0.00
CO2 / CO2 equ. [kg] 0.302000 48 991.00 849.00 9789.00 368.00
NOx [kg] 0 0.000878 0 1.17 0.29 0.35 0.16
SO2 [kg] 0.001700 0 5.30 1.70 13.40 0.29
> E
[ ,1]
Diesel [kg] 0
Bauxite, at plant [kg] 0
Alumina [kg] 0
Anode [kg] 0
Aluminium (liquid metal) [kg] 0
Ingot [kg] 1000
> s
[ ,1]
Diesel prod. 11.345994
Bauxite mining 4.517378
Alumina prod. 1.682450
Anode prod. 0.385494
Electrolysis 0.674000
Ingot casting 1.000000
> g
[ ,1]
Crude oil [kg] -17.018990
Bauxite [kg] -4517.378250
CO2 / CO2 equ. [kg] 11138.988062
NOx [kg] 2.556104
SO2 [kg] 21.593111
> I

```

$$s = A^{-1} \cdot f$$

$$g = B \cdot s$$

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## Impact Assessment methods

- ◆ There are **no impact assessment methods included** by default in openLCA, but methods are available for free and can be easily imported
- ◆ It is possible to **modify existing impact assessment methods** in openLCA (impact categories and flows can be added / deleted; equivalence factors can be altered)
- ◆ It is also possible to create **new impact assessment methods** ; parametrization is also available

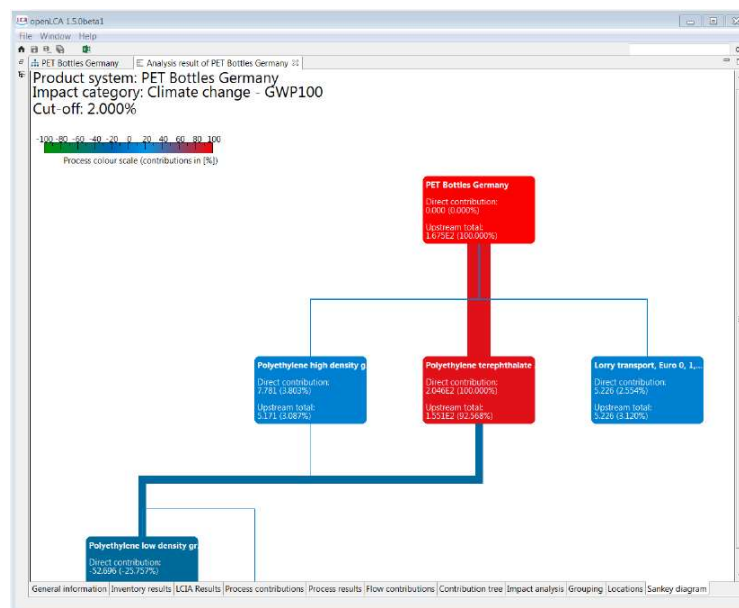
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## Analysis and interpretation

- ◆ In openLCA many functions are available to evaluate the results and to track the origin of environmental effects:
  - ◆ Various result and influence analyses
  - ◆ Sankey Diagram
  - ◆ Representation of the spatial distribution of emissions and resource consumption
  - ◆ Grouping of processes is possible (e.g. by life cycle phase)
  - ◆ ...

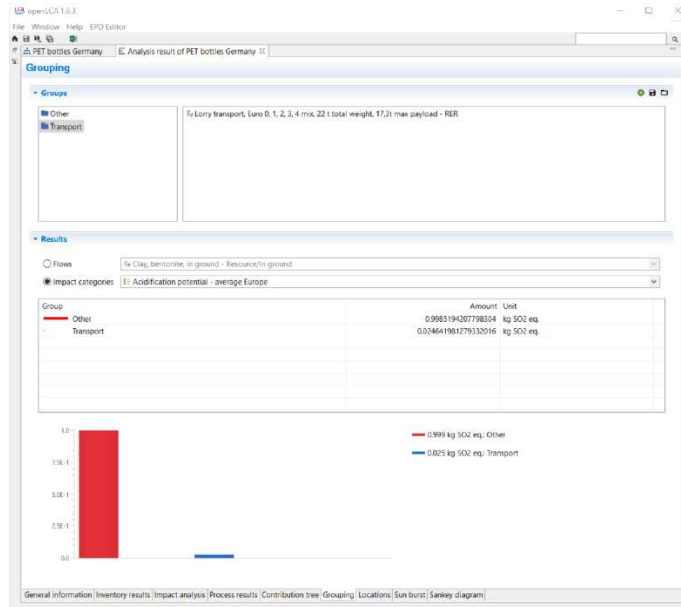
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## Sankey Diagram



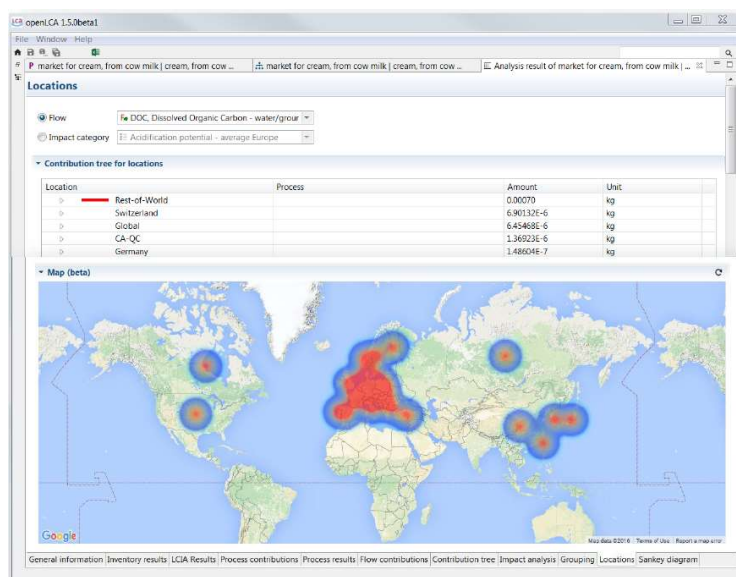
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## Grouping



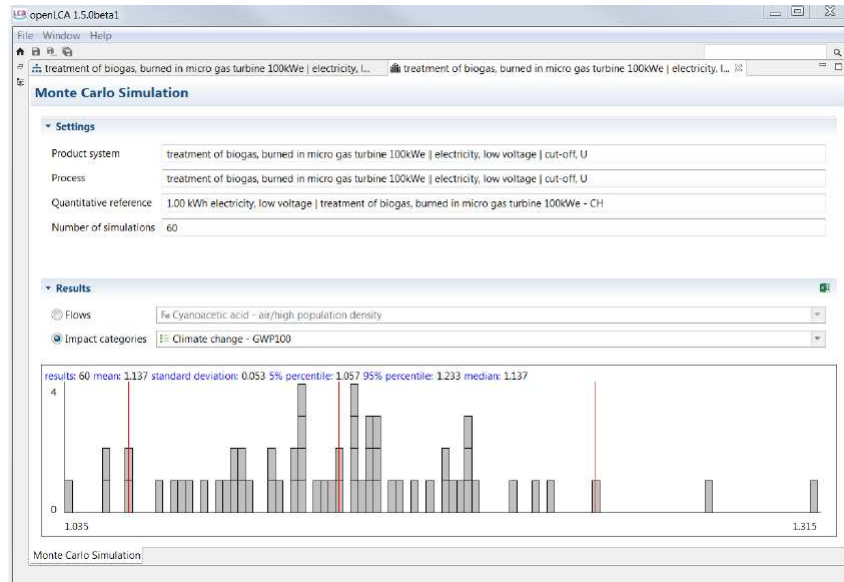
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## Localisation



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## Uncertainty Analyses

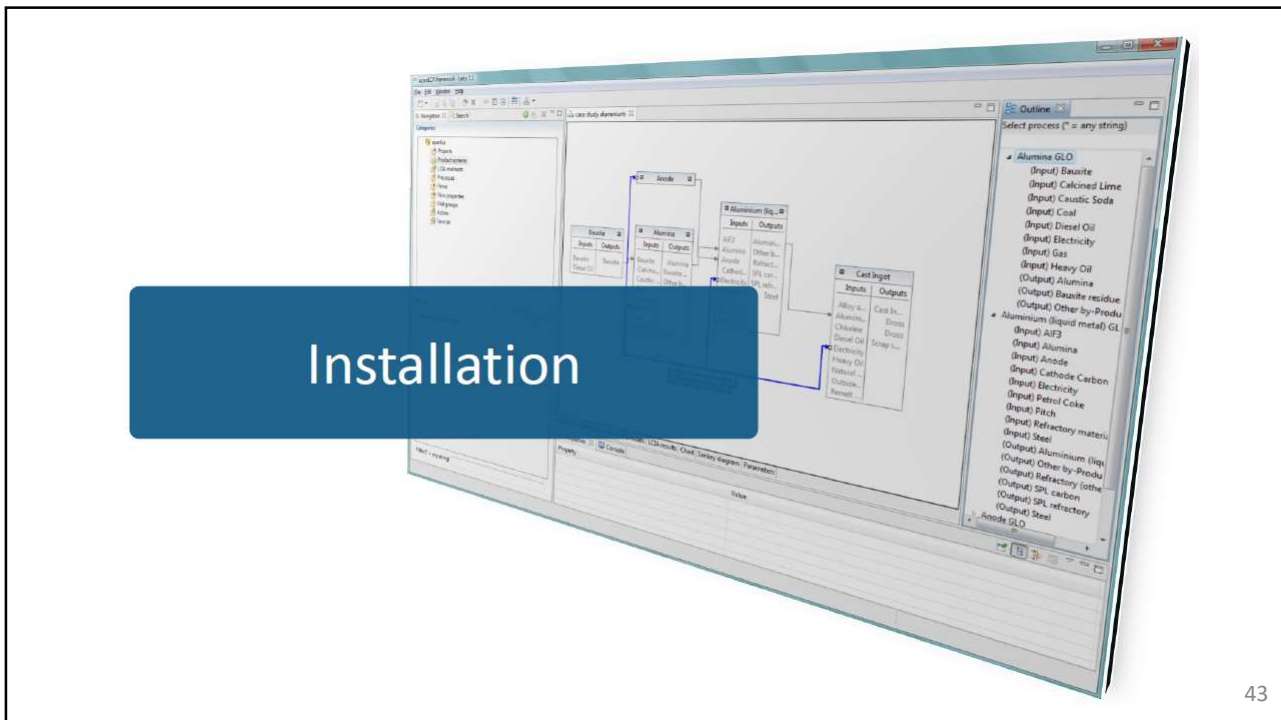


41

## Further characteristics

- ◆ Separate calculation of costs possible
- ◆ Regionalized impact assessment possible
- ◆ Multiple languages
- ◆ Automatic error report
- ◆ Integrated static and dynamic help

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## System requirements

### Software, required:

- Mac OS: Java Development Kit 8 (<http://www.oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html>)

### Software, optional:

- Windows 64 bit (for modern browser support): Microsoft Visual C++ 2010 Redistributable Package (x64) (<http://www.microsoft.com/de-de/download/details.aspx?id=14632>)
- Linux (for high performance calculations): libgfortran3

### Hardware:

- CPU with 2 GHz or higher
- 1 GB RAM (for analyzing product systems with ~2500 processes, like ecoinvent 2)
- > 3 GB RAM (for analyzing product systems like ecoinvent 3)
- 500 MB free disk space + space for databases (e.g. ecoinvent 3 requires ~250 MB)

44

## Task #1: Download and installation of openLCA

- ◆ Download openLCA @ <https://www.openlca.org/download/>

Downloads



openLCA

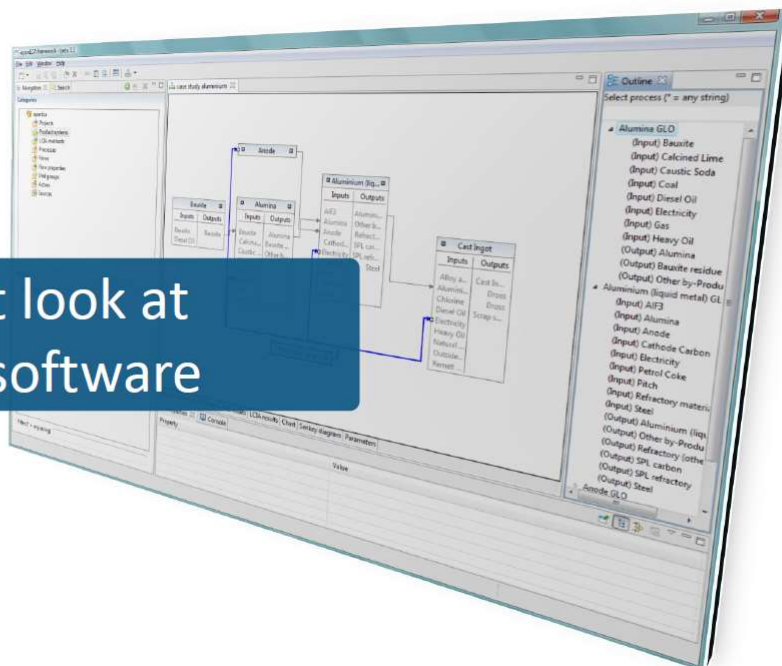
Here's presenting the latest version 1.10.3 (release date: June 24th, 2020). We recommend using this version. Our tests have not shown any issues, but should you run into any, please let us know. Thanks in advance!

Windows	Mac	Linux	Sources	Latest build
<p>To use openLCA in windows, download the zip-archive below: just unzip the archive and start openLCA.exe. To uninstall it, just delete the created folder. You can have several versions of openLCA in different folders on the same computer.</p> <p>openLCA 1.10.3 zip-archive: <a href="#">openLCA_win64_1.10.3_2020-06-24.zip</a></p> <p>Alternatively, you can install openLCA with the installer below. If you have an older openLCA version installed (via the installer) you should uninstall it first.</p> <p>openLCA 1.10.3 installer: <a href="#">openLCA_win64_1.10.3_2020-06-24</a></p>				

- ◆ Two options available: Installer version and zip file

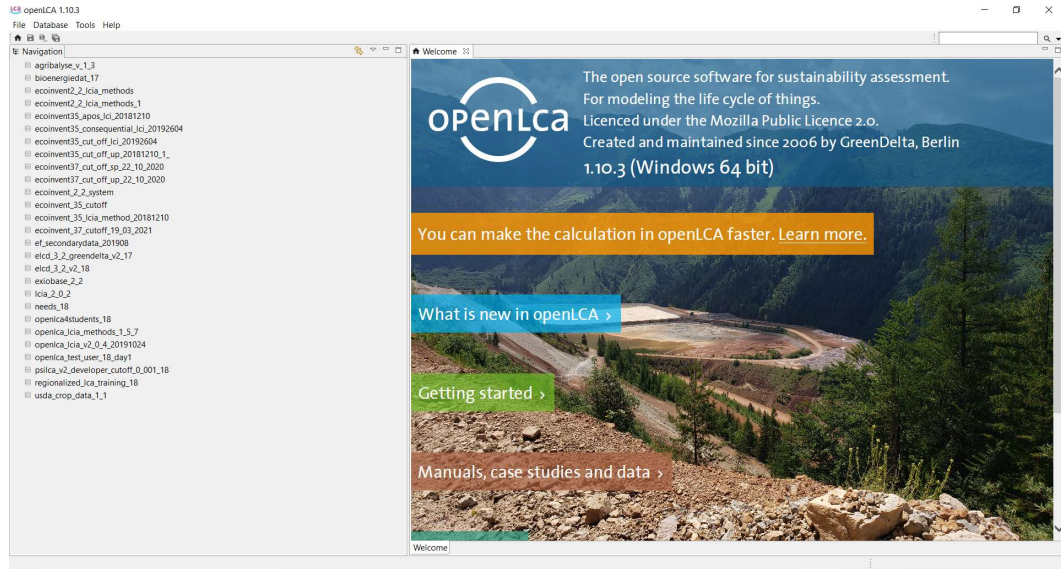
45

First look at  
the software



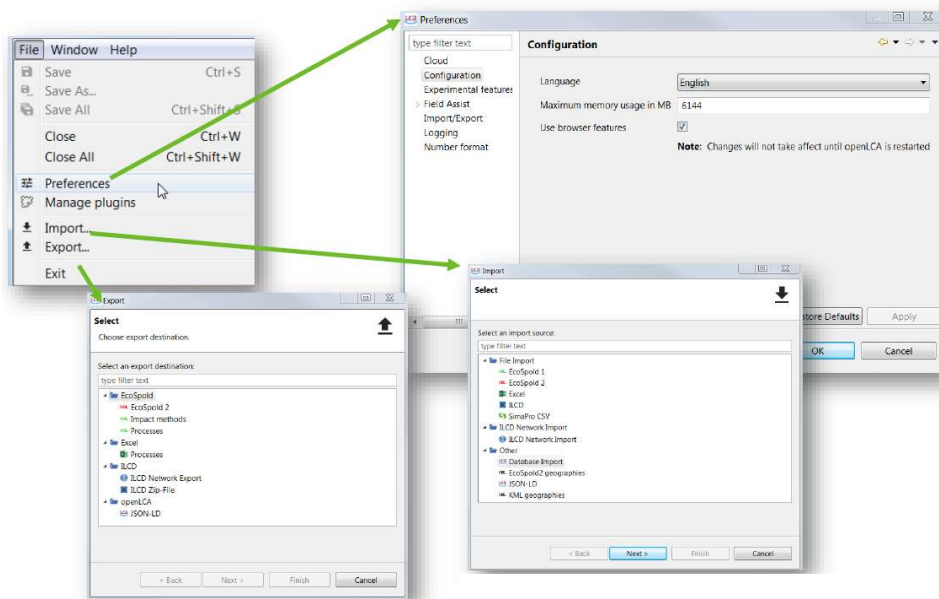
46

## Homepage



47

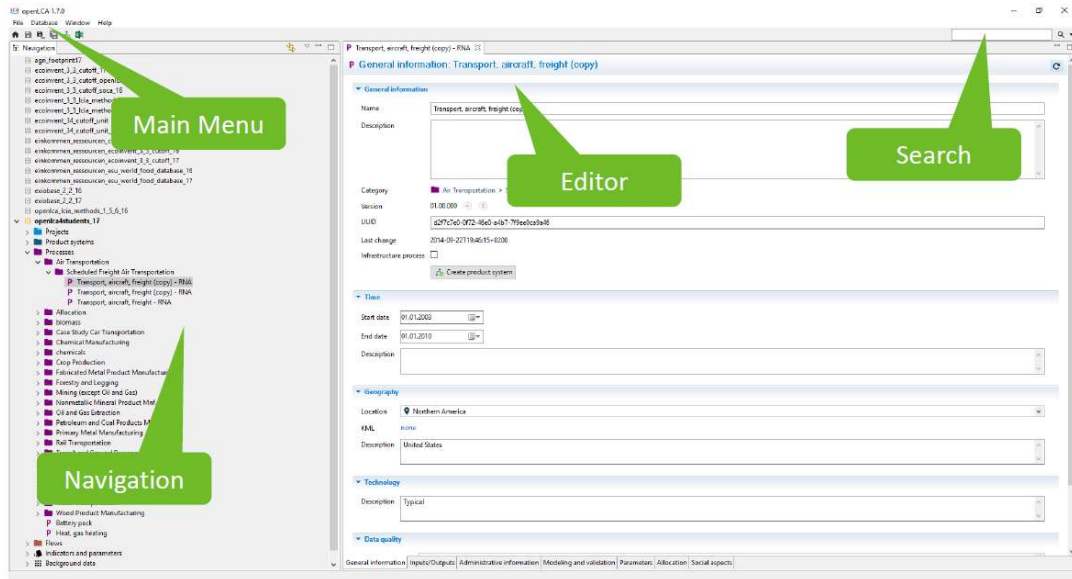
## Main menu functions



48

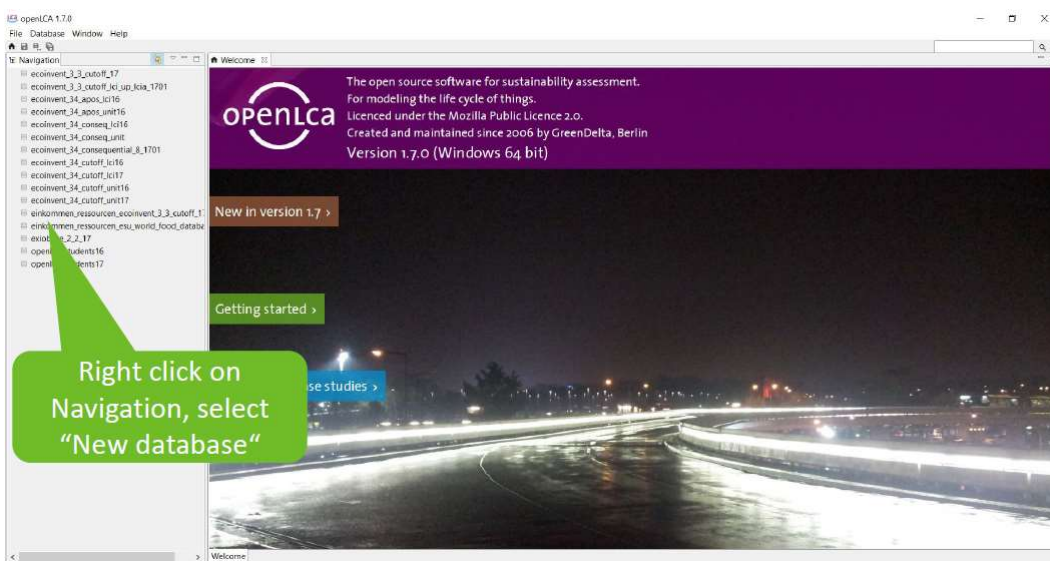


## openLCA overview



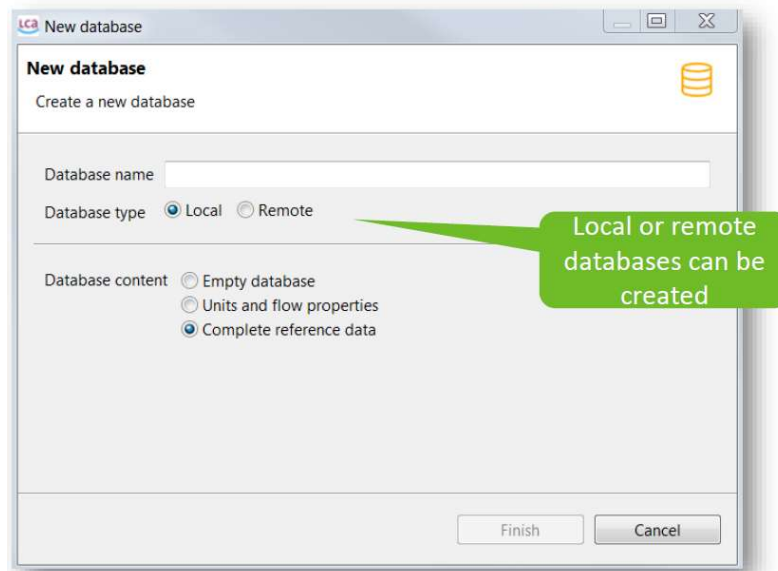
49

## Create a new database



50

## Create a new database (local)

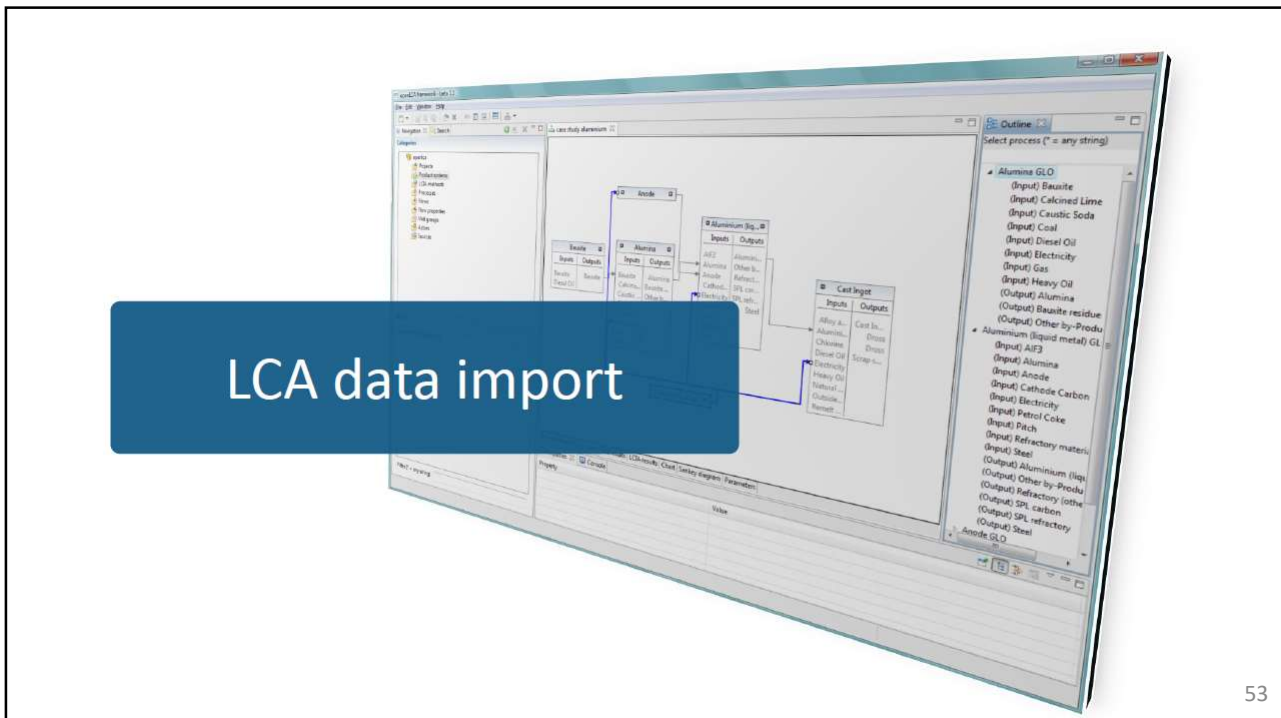


51

## Task #2: Create a new database

- ◆ Create a local database
- ◆ Accept default values (local database & complete reference data)

52



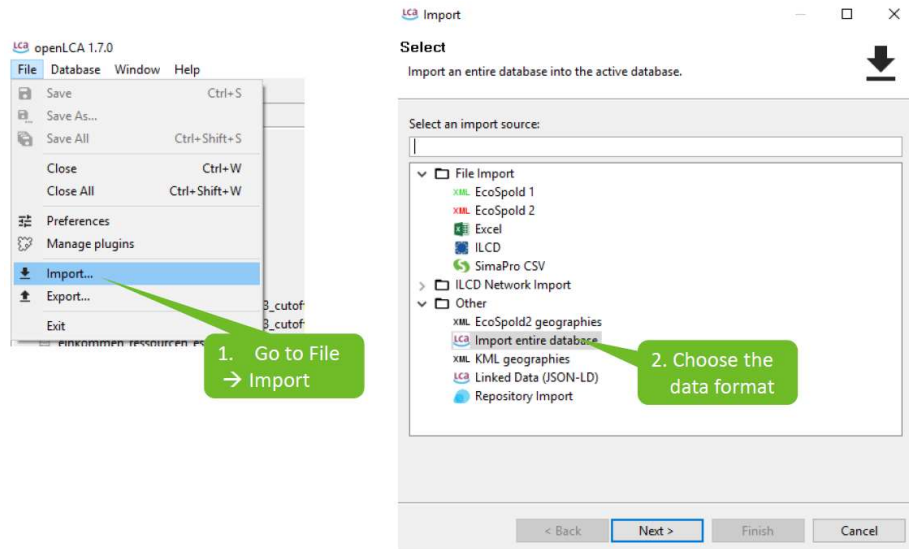
53

## Data management in openLCA

- ◆ New databases in openLCA are empty at first (with the exception of reference data), but data can be imported easily
- ◆ Supported Import and Export formats:
  - ◆ EcoSpold1 (ecoinvent format)
  - ◆ ILCD (zip format)
  - ◆ EcoSpold2 (ecoinvent format)
  - ◆ Excel
  - ◆ SimaPro CSV (modified version of Ecospold, used by SimaPro)
  - ◆ Zolca (openLCA format)
- ◆ It is possible to use more than one database; databases are independent of one another and only one database is “active” at a time, all of the others are “deactivated”
- ◆ It is possible to save own data; every element of the software can be personalised

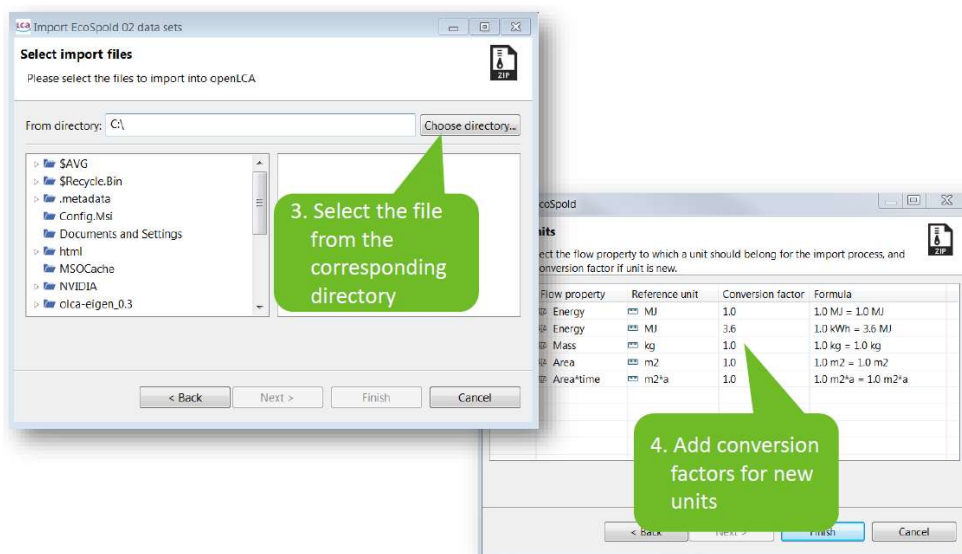
54

## Import data sets



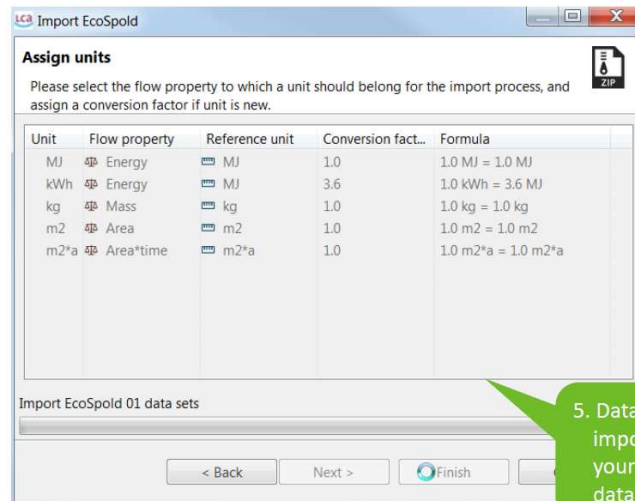
55

## Import data sets (II)



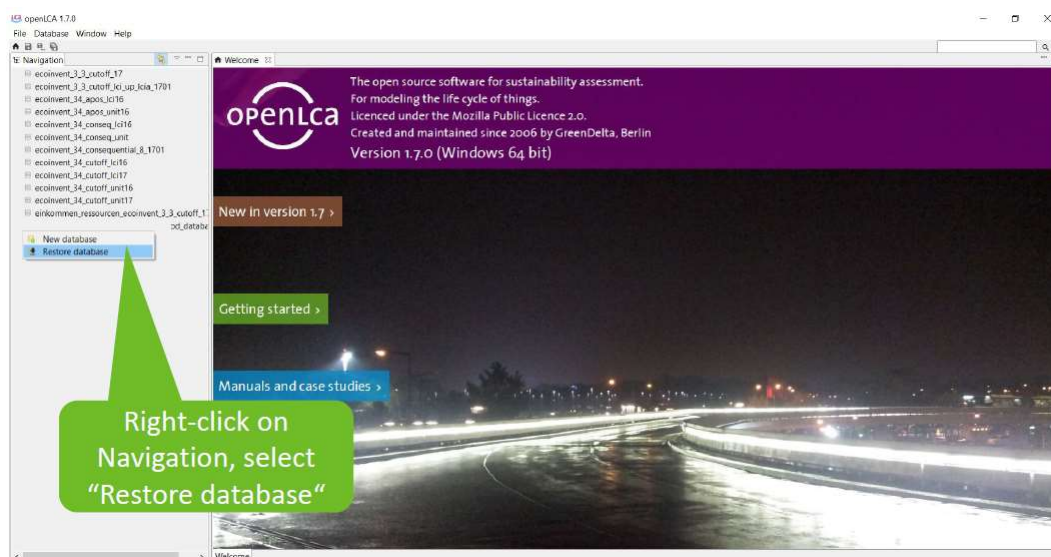
56

## Import data sets (III)



57

## openLCA database import



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## openLCA Nexus

- ◆ LCA data web repository @ <https://nexus.openlca.org/>
- ◆ Direct purchase/download of data mainly for use with openLCA (some databases for SimaPro, too)



openLCA Nexus Databases Services Case studies LCA data search Map Documents FAQs About

**openLCA nexus**

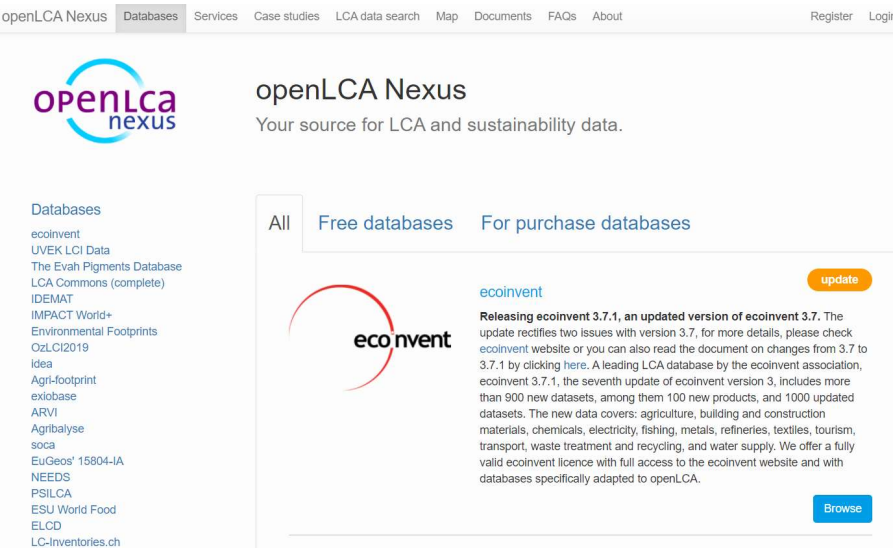
openLCA Nexus  
Your source for LCA and sustainability data.

**Search**

Overall providing > 250,000 data sets.  
**Agribalyse 3 now available!**  
e.g. for Switzerland: 51978 data sets found.

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## openLCA Nexus (II)



openLCA Nexus Databases Services Case studies LCA data search Map Documents FAQs About Register Login

**openLCA nexus**

openLCA Nexus  
Your source for LCA and sustainability data.

Databases

- ecoinvent
- UVEK LCI Data
- The Evah Pigments Database
- LCA Commons (complete)
- IDEMAT
- IMPACT World+
- Environmental Footprints
- OzLCI2019
- Idea
- Agri-footprint
- exiobase
- ARVI
- Agribalyse
- soca
- EuGeos' 15804-IA
- NEEDS
- PSILCA
- ESU World Food
- ELCD
- LC-Inventories.ch

All **Free databases** For purchase databases

**ecoinvent** **update**

**Releasing ecoinvent 3.7.1, an updated version of ecoinvent 3.7.** The update rectifies two issues with version 3.7, for more details, please check [ecoinvent website](#) or you can also read the document on changes from 3.7 to 3.7.1 by clicking [here](#). A leading LCA database by the ecoinvent association, ecoinvent 3.7.1, the seventh update of ecoinvent version 3, includes more than 900 new datasets, among them 100 new products, and 1000 updated datasets. The new data covers: agriculture, building and construction materials, chemicals, electricity, fishing, metals, refineries, textiles, tourism, transport, waste treatment and recycling, and water supply. We offer a fully valid ecoinvent licence with full access to the ecoinvent website and with databases specifically adapted to openLCA.

**Browse**

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## openLCA Nexus (III)



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## openLCA Nexus search engine

### ◆ Multiple filtering options:

- ◆ Name
- ◆ Database
- ◆ Location
- ◆ Type of dataset
- ◆ Category
- ◆ Start of validity
- ◆ Price

openLCA Nexus Databases Services Case studies LCA data search Map Documents FAQs About Register Login 0

**openLCA Nexus**  
Your source for LCA and sustainability data.

PET Search Options

2330 data sets

**P** PET granulates, amorphous, production mix, at plant, Polymerisation of ethylene, 0.91-0.96 g/cm<sup>3</sup>, 28 g/mol per repeating unit  
Plastics  
Databases: PEF database  
Location: EU-28+EFTA  
Validity: 2013 - 2020

**P** polyethylene terephthalate, granulate, amorphous, recycled to generic market for amorphous PET granulate | polyethylene terephthalate, granulate, amorphous, recycled  
E:Water supply; sewerage; waste management and remediation activities/38:Waste collection, treatment and disposal activities; materials recovery/383:Materials recovery/3830:Materials recovery  
Databases: econvent v2.2 & v.3.7.1  
System model: Consequential long-term  
Location: Switzerland

**Model type** more  
Process 2329  
Product system 1

**(Background) Database** more  
Agribalyse 1809  
EuGeos 15804-IA 136  
ESU World Food 127  
econvent 102  
econvent v2.2 & v.3.6 66  
Environmental Footprints 50  
econvent v2.2 & v.3.4 48  
soca 29  
IDEMAT 27  
ProBas 13  
more...

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## Task #3: Import ELCD database

- ◆ Restore the database ELCD in openLCA
- ◆ Import the openLCA LCIA methods within the database



Info Details Documents

European reference Life Cycle Database of the Joint Research Center. Version 3.2 from October 2015. Obvious errors in the original database provided by JRC were corrected (missing data sets), elementary flows were mapped to openLCA reference list and some refactoring in categories was conducted.

ELCD Database details

LCA 1.8-1.10 LCA 1.7 LCA 1.6 LCA 1.5 LCA 1.4/1.5

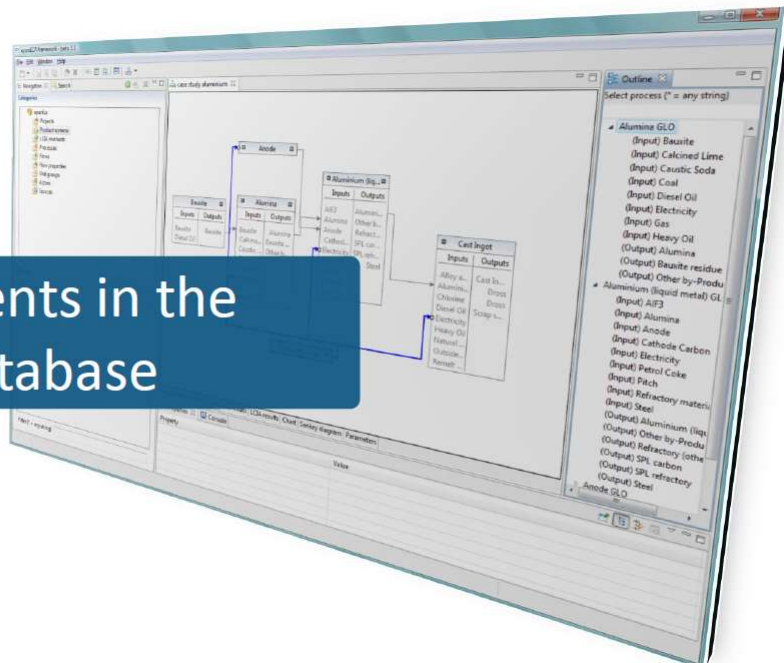
ELCD

Free

Go to downloads

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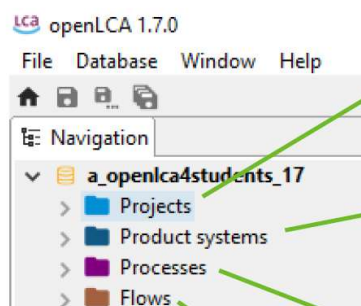
Elements in the database



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## Database elements



**Projects:** comparison of numerous product systems

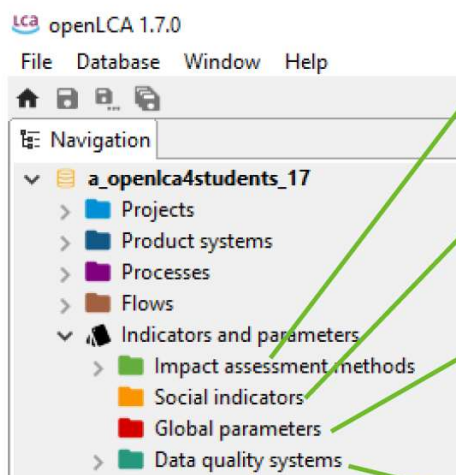
**Product systems:** process networks (necessary to calculate inventory results and impact assessment)

**Processes:** Production or modification of materials/products

**Flows:** Flow of products and materials and elementary flows

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## Database elements (II)



**LCA Methods:** can be downloaded at [openlca.org/downloads](http://openlca.org/downloads)

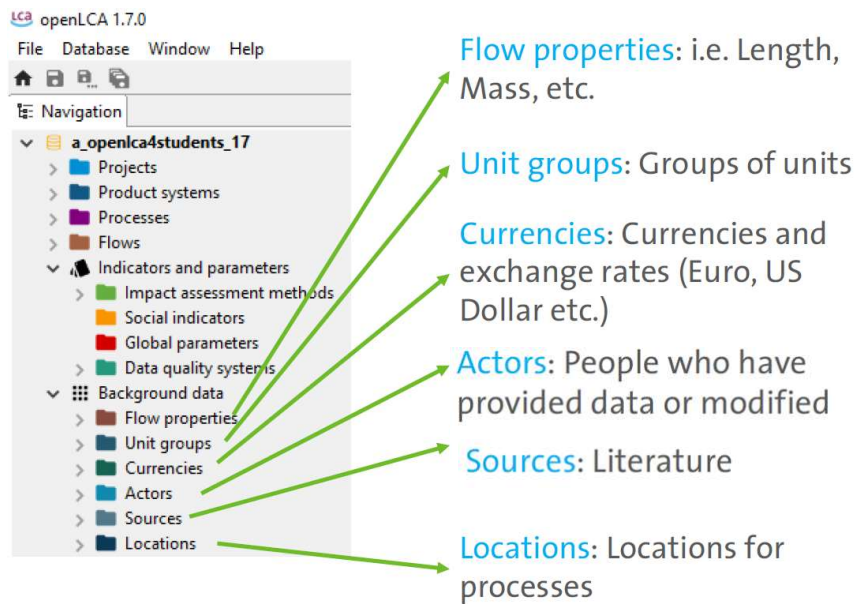
**Social indicators:** Indicators for social LCA

**Global parameters:** Parameters that are available within the whole database

**Data Quality Systems:** Systems for defining the data quality of processes and exchanges

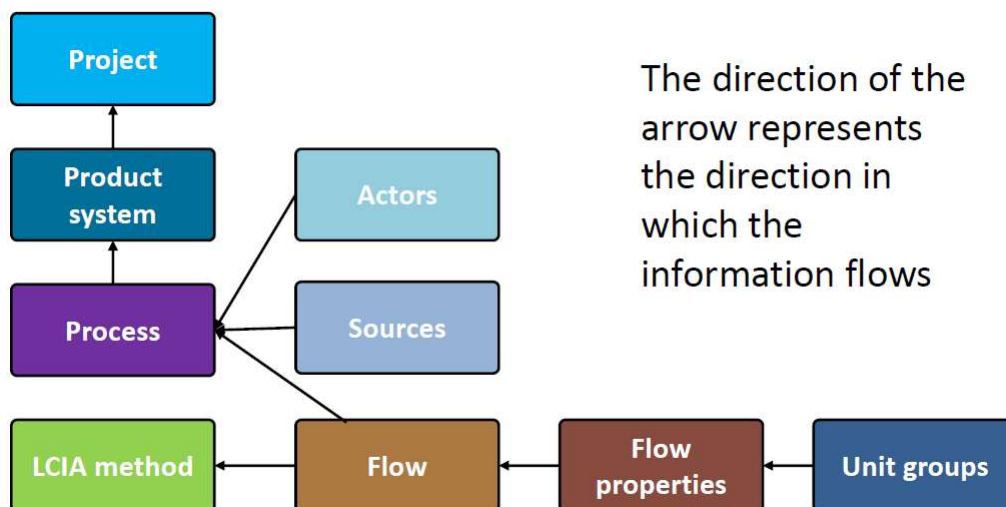
66

## Database elements: Background data

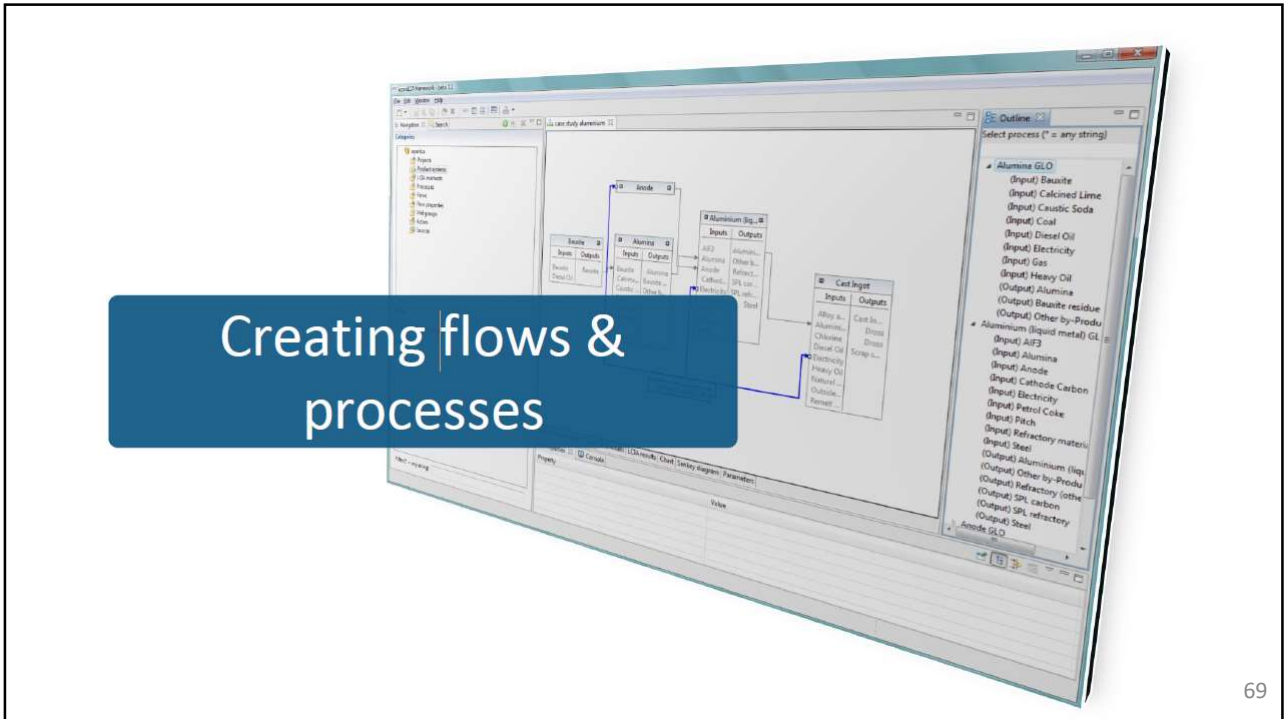


67

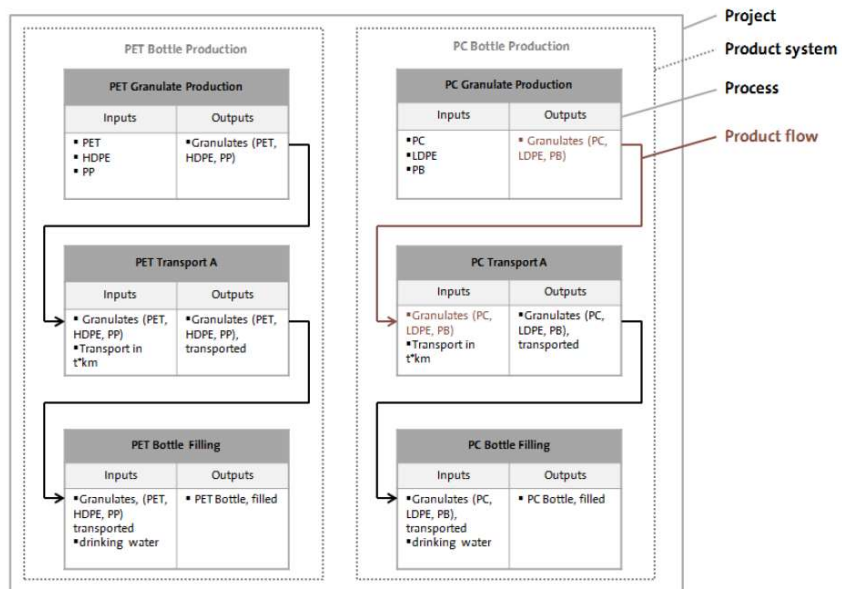
## Elements structure in openLCA



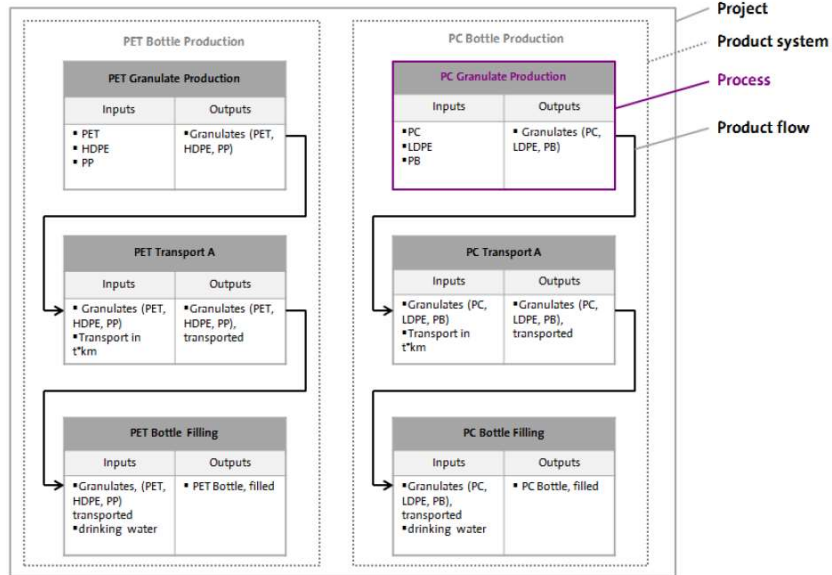
68



## Database Modeling in openLCA: Flows



## Database Modeling in openLCA: Processes



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## Flows: Create a new flow

The screenshot shows the openLCA 1.5.0beta1 software interface. The 'Flows' folder is selected in the left navigation pane, and a context menu is open with 'New flow' highlighted. A green callout box points to this menu item with the text: "1. right click on 'Flows' folder, select 'create new flow'". The main window shows the 'Flow: Electricity, at grid, MX' properties.

**Flow: Electricity, at grid, MX**

**General information**

Name: Electricity

Description:

Product flows: 01.00.000

Change: 2014-09-22T19:46:12+0200

Infrastructure flow:

Flow type:  Product

**Used in processes**

**Additional information**

CAS number:

Formula:

Synonyms:

Location:

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## Flows: Create a new flow (II)

Flow: Electricity, at grid, MX

**New flow**  
Creates a new flow

Name: Flow name

Description:

Flow type: Product

Reference flow property: Mass

Buttons: Finish, Cancel

Additional information:

CAS number:

Formula:

Synonyms:

Location:

General information | Flow properties

1 item selected

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## Flows: Create a new flow (III)

Flow: Electricity, at grid, MX

**Flow properties**

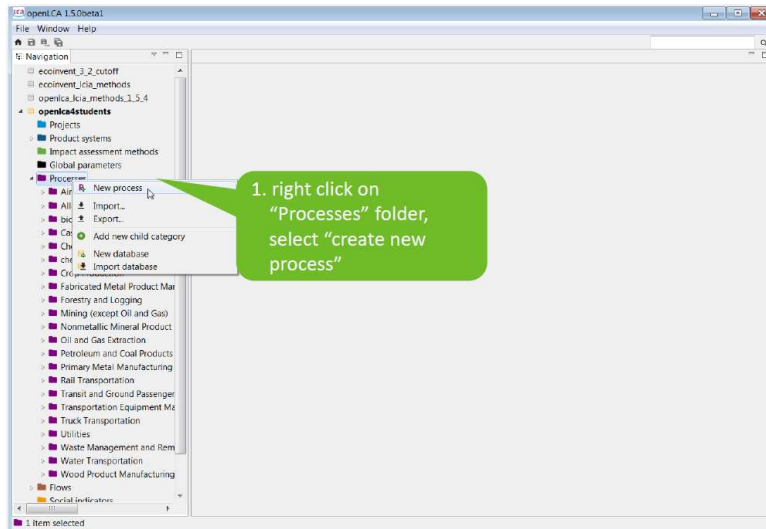
Name	Conversion factor	Reference unit	Formula	Is reference
Energy	1.0	MJ	1.0 MJ = 1.0 MJ	<input checked="" type="checkbox"/>

General information | Flow properties

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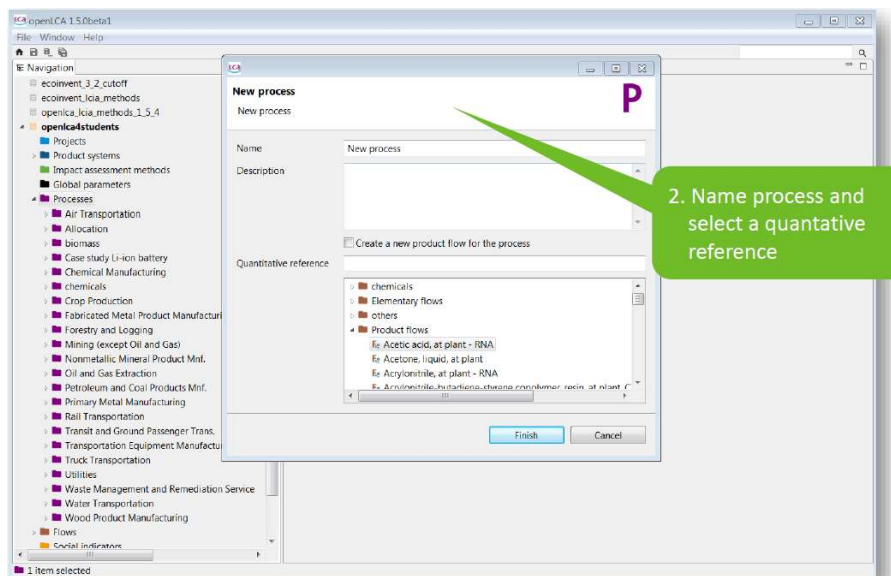


## Process: Create a new process



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## Process: Create a new process (II)



78

## Process: Create a new process (III)

3. A new process window will open up in the editor. Description, time, geography, etc. data can be added in the "General Information" tab

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## Process: General information

Process: ammonium bicarbonate production | ammonium bicarbonate | cut-off, U

**General information**

Name: ammonium bicarbonate production | ammonium bicarbonate | cut-off, U

Description: Manufacturing process is considered with consumption of raw materials, energy, as well as infrastructure and land use. Transport and storage of the final product are not included due to the lack of data. Transport and storage of the final product are not included due to the lack of data. Inventory refers to 1 kg 100% ammonium bicarbonate. Data for consumption of energy have been provided by a manufacturer used in von Däniken et al. 1995. This dataset was already contained in the ecoinvent database version 2. It was not individually affected by changes in the supply chain, i.e. in other datasets. This dataset was generated following the ecoinvent quality guide.

Category: C-Manufacturing > 20.Manufacture of chemicals and chemical products > 201.Manufacture of basic chemicals, fertilizers and

Version: 03.114.000

UUID: f6532a34-dc01-3cf4-a344-9004f6451426

Last change:

Infrastructure process:

[Create product system](#)

**Quantitative reference**

Quantitative reference: F<sub>0</sub> ammonium bicarbonate | ammonium bicarbonate production (RER)

**Time**

Start date: 1/1/1995

End date: 12/31/2015

Description: Values based on data from the early 1990s.

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## Process: Inputs/Outputs

Process: ammonium bicarbonate production | ammonium bicarbonate | cut-off, U - RER

Process: ammonium bicarbonate production | ammonium bicarbonate | cut-off, U

Flow	Category	Amount	Unit	Costs	Uncertain...	Provider	Pedigree ...	De...
Fe ammonia, liquid   mark...	201Manufacture ...	0.22700	kg			lognorm...	P marke...	
Fe chemical factory, organ...	429Construction ...	4.90000E-10	Item(s)			lognorm...	P marke...	
Electric power...		0.32300	kWh			lognorm...	P marke...	
Manufacture ...		0.58600	kg			lognorm...	P marke...	
Water in water		0.24000	m3			lognorm...		

4. Additional flows can be added in the "Input/Output" tab.

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## Process: Administrative Information & Modeling and validation

Administrative information

Intended application

Data set owner

Data generator: Maggie Osse

Data documentor: Maggie Osse

Publication: Althaus H.-J., et al. 2007

Access and use restrictions

Project

Creation date: 7/28/10 6:07 PM

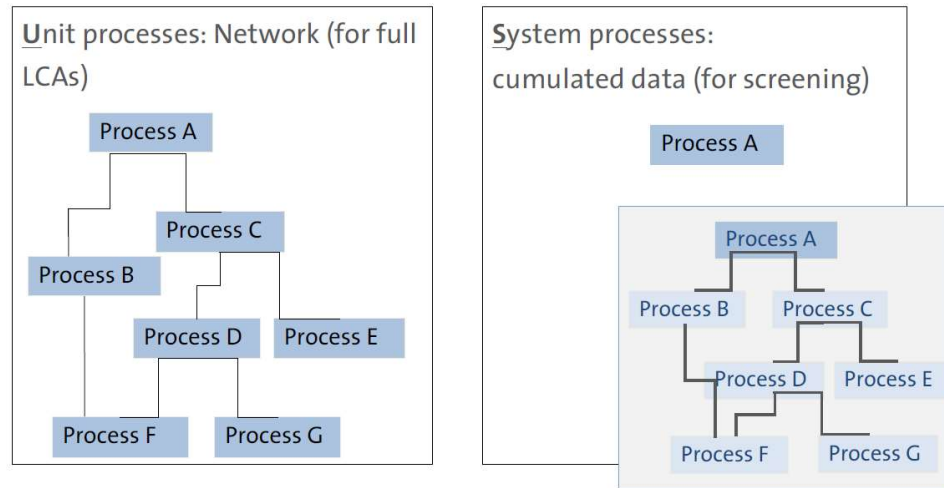
Copyright

5. Additional metadata can be included in the "Administrative information" and "Modeling and validation" tabs

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## Dataset in LCI databases

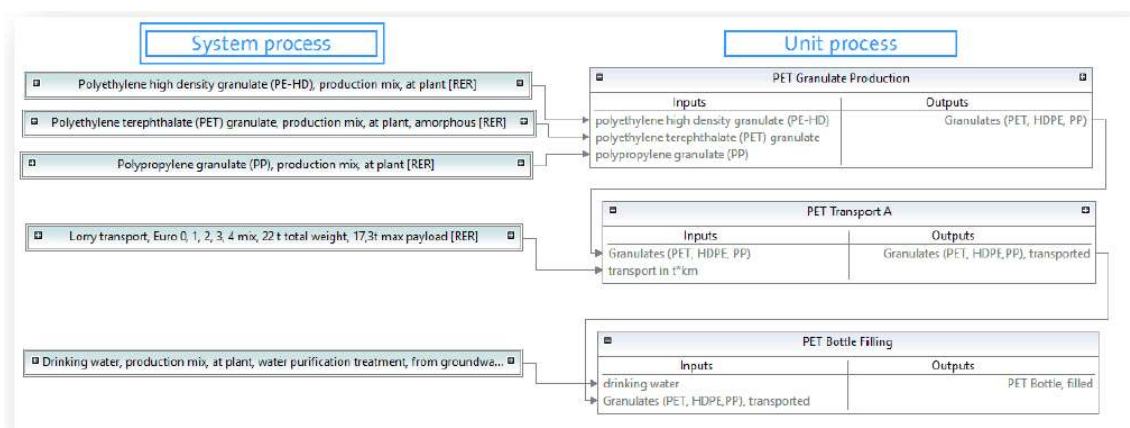
- ◆ecoinvent database includes Unit & System Processes



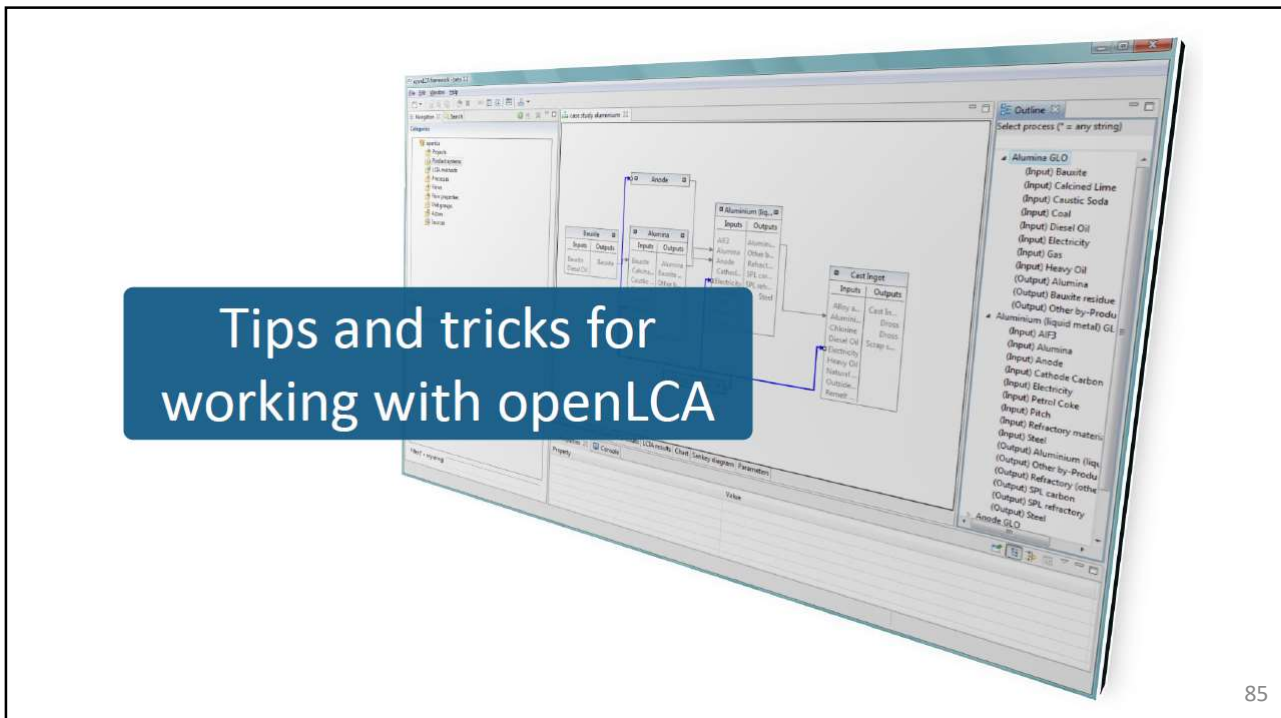
83

## Dataset in LCI databases

- ◆ecoinvent database includes Unit & System Processes



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## Basic commands

Open element: double click

Copy element: right mouse button → copy

Paste element: right mouse button → paste

Delete element: right mouse button → delete

Save element: use saving symbol in the main menu



Save image: right mouse button → save image

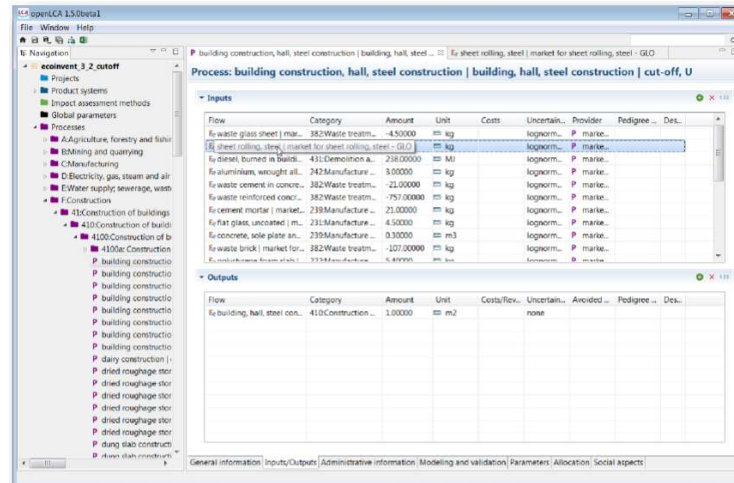
Minimise/maximise element:



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## Basic commands

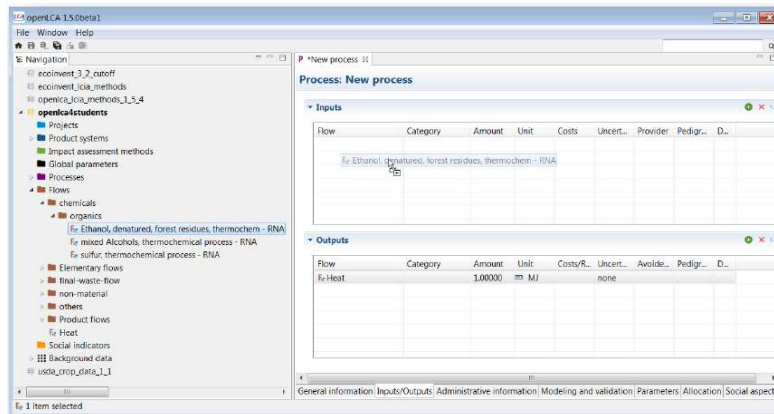
- ◆ If you double click on a flow in the process editor it will be opened in a separate window and can be modified:



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## Basic commands

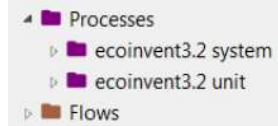
- ◆ Drag and drop flows from the Navigation pane to the Input/Outputs tab in the process editor
- ◆ Drag and drop processes from the Navigation pane to the Model Graph in the product system editor



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## Folder structure

- ◆ Divide system and unit processes



- ◆ Divide processes from different databases in openLCA database list
- ◆ Separate flows and processes that were created on your own

Do not change the folder structure of elementary flows, because otherwise the LCIA cannot find them anymore!

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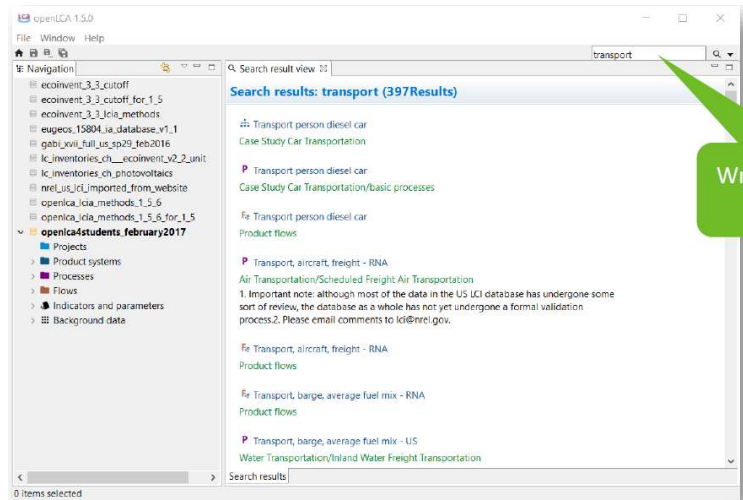
## Windows

- ◆ Often users have several elements open at the same time; it is recommended to close elements you don't need
- ◆ To recover "missing" window: go to Window → Show → View → Other
- ◆ It is also possible to change the position of a window

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## Search

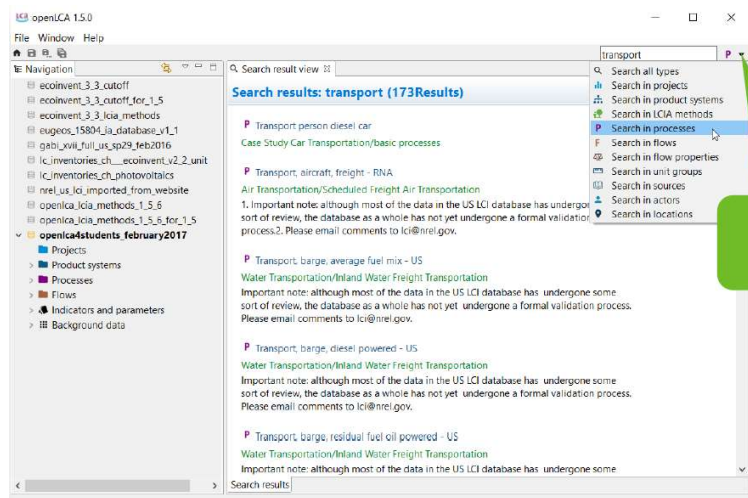
- ◆ Search any elements from the database



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## Search (II)

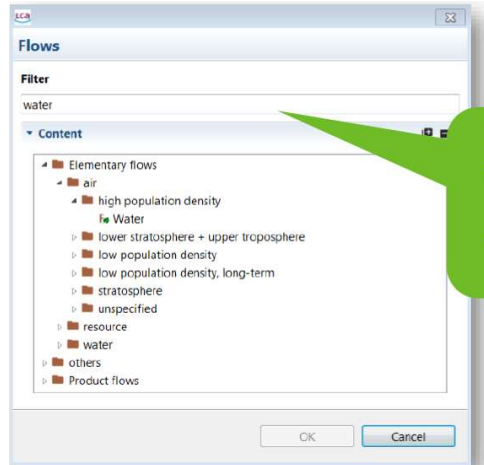
- ◆ Search within a specific element from the database



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## Filter

- ◆ The “add new” editors contain a filter for facilitating the search of the desired element

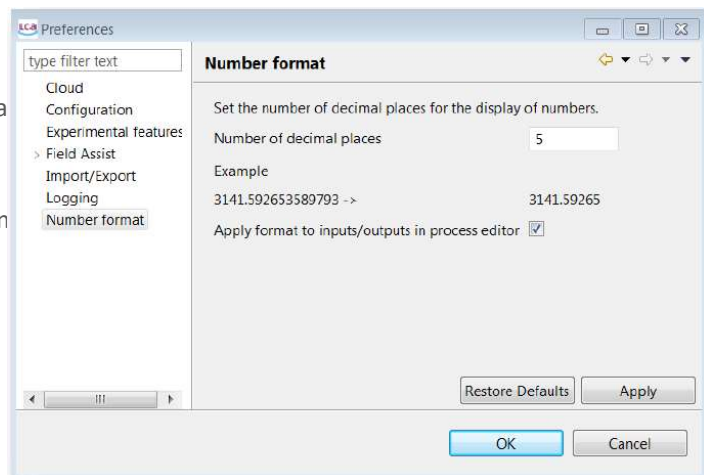


Use the “Filter” when adding new flows to a process, select the reference process in a product system, etc.

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## Numbers

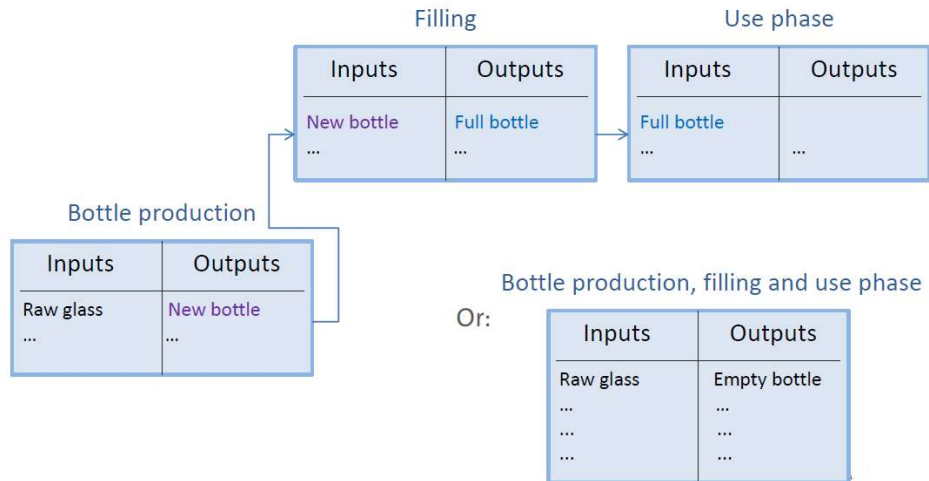
- ◆ Use always a point for floating point numbers, a comma is not accepted (1.5 instead of 1,5)
- ◆ Under File/Preferences/Number format you can choose the number format of results



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## Modeling with product flows

- Use different flow names for one flow that “hikes” through your product system



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## Modeling with product flows

- The default provider can be set for each exchange

\*Transport, aircraft, freight - RNA

**Process: Transport, aircraft, freight**

Inputs

Flow	Category	Amount	Unit	Costs	Uncertai...	Provider	Pedigree...	De...
Kerosene, at refinery -...	Product flows	0.4199197...	L		none	None		
						None		
						Petroleum refining, at refinery - RNA		
						Crude oil, in refinery - RNA		

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## Plastic bottle for drinking water PET vs PC

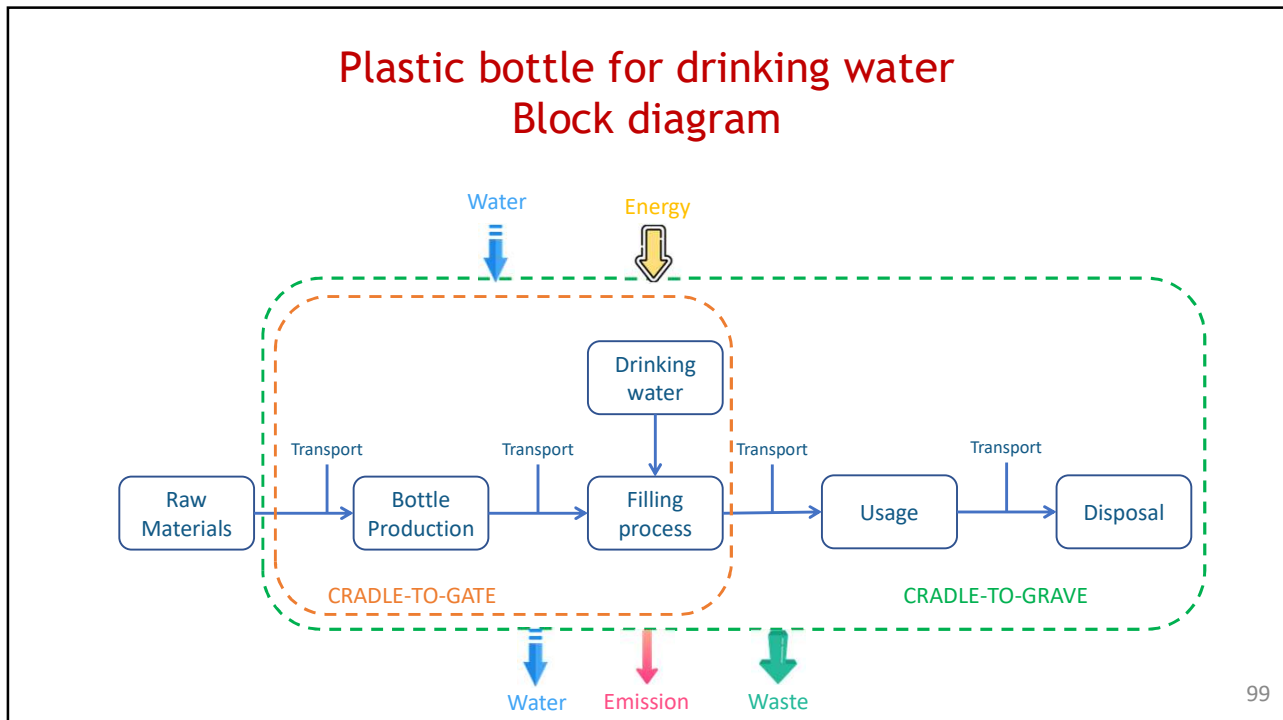


97

## Plastic bottle for drinking water PET vs PC

- ◆ **Goal:** Conduct an LCA of one PET water bottle produced and consumed in Italy from cradle to gate
- ◆ **FU:** 1 bottle containing 1 litre of still water
- ◆ Production chain
  1. Plastic granulate production:
    - ◆ polyethylene terephthalate granulate (PET) for the bottle (bottle grade, RER)
    - ◆ Polyethylene high density granulate (PE HD) for the lid ( RER
    - ◆ Polypropylene granulate (PP) for the labels (RER)
  2. Transport of PET, HDPE and PP granulates for further processing (Transport A)
  3. Production of a PET pre form bottle, the HDPE lid and the PP label from the respective granulates produced in step 1.
  4. Transport of bottle pre form, lid and label to bottle filling location (Transport B)
  5. Blow PET bottle, fill with water and attach lid and label

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## Task #5: Creation of a process

- ◆ Create a new folder for this case study within the Processes folder
- ◆ Create a new process called "Production of PET granulates"

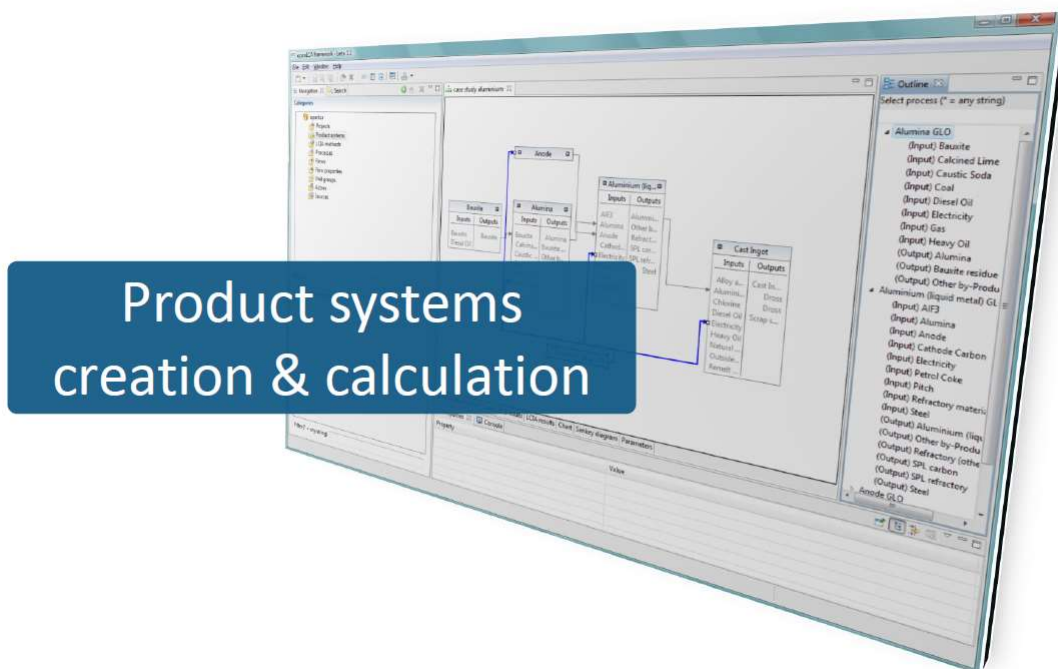
Input	Amount	Unit
Polyethylene high density granulate (PE-HD)	0.004	kg
Polyethylene terephthalate (PET) granulate	0.06	kg
Polypropylene granulate (PP)	0.001	kg
Output	Amount	Unit
PET granulates	0.065	kg

- ◆ Remember to add the provider for the raw materials
- ◆ For the production of the bottles, lids and labels, it is assumed that 100% of the respective granulate is utilized in forming the final product, without waste

## Task #5: Creation of processes (II)

- ◆ Create a new process called “PET transport A”
  - ◆ The reference flow is called “PET granulates, transported”, expressed in mass units
  - ◆ The mix of PET granulates need to be transported for 200 km using a medium-sized lorry
- ◆ Create a new process called “PET Production of bottle preform, lid and lable”
  - ◆ The reference flow is called “PET empty bottle”, expressed in number of items
  - ◆ The production of 1 bottle made of 0.065 kg of “PET granulates, transported” needs 1 MJ of in medium voltage (MV) of electricity for a grid European average consumer mix
- ◆ Create a new process called “PET empty bottle, transported”
  - ◆ The reference flow is called “PET empty bottle, transported”, expressed in number of items
  - ◆ The bottle needs to be transported for 100 km using a medium-sized lorry
- ◆ Create a new process called “PET full bottle”
  - ◆ The reference flow is called “PET full bottle”, expressed in number of items
  - ◆ The bottle needs to be filled with 1 kg of drinking water (find the right provider!)
  - ◆ The filling process requires 2 MJ of MV electricity from the European average grid consumer mix

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## Product system: Creation

1. Click on "Create product system" in the General information tab

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## Product system: Creation (II)

2. Name the product system and select a reference process

3. Select the modeling options preferred

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## Product system: General Information

openCA 1.5.0beta1

File Window Help

Product system: beet sugar production | molasses, from sugar beet | cut-off, U

**General information**

Name: beet sugar production | molasses, from sugar beet | cut-off, U

Description:

Version: 00.00.000

UUID: ada53e62-03e9-4b65-aace-8aa0b6a57109

Last change:

**Reference**

Process: P beet sugar production | molasses, from sugar beet | cut-off, U

Product: F<sub>1</sub> molasses, from sugar beet | beet sugar production (CH)

Flow property: Mass

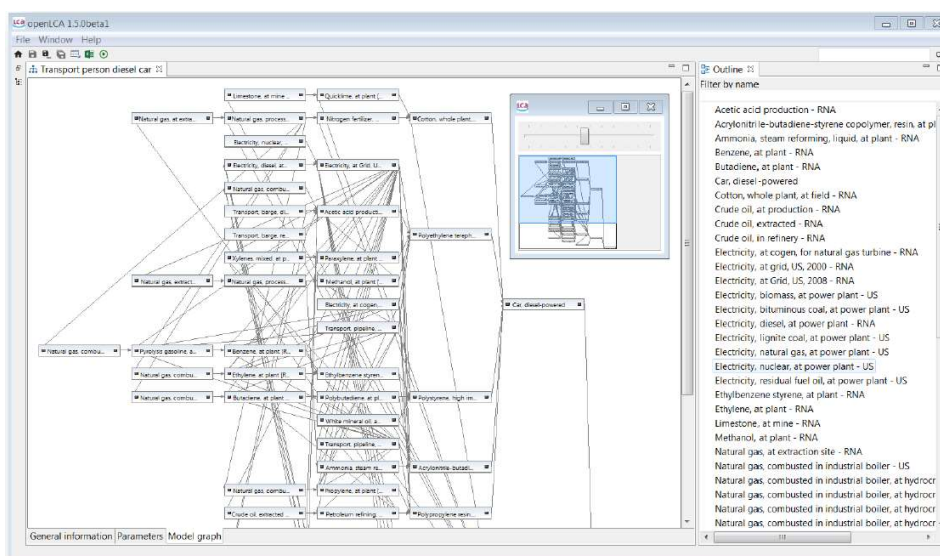
Unit: kg

Target amount: 1.0

General Information Parameters Model graph

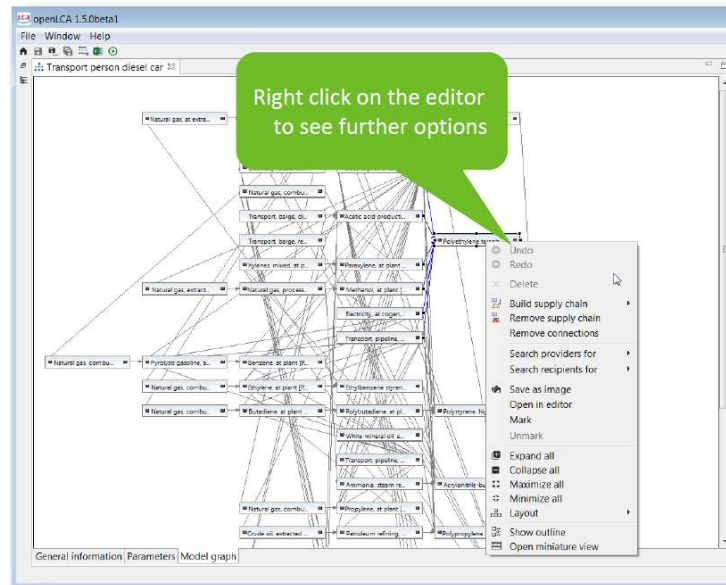
105

## Product system: Model Graph



106

## Product system: Model Graph (II)



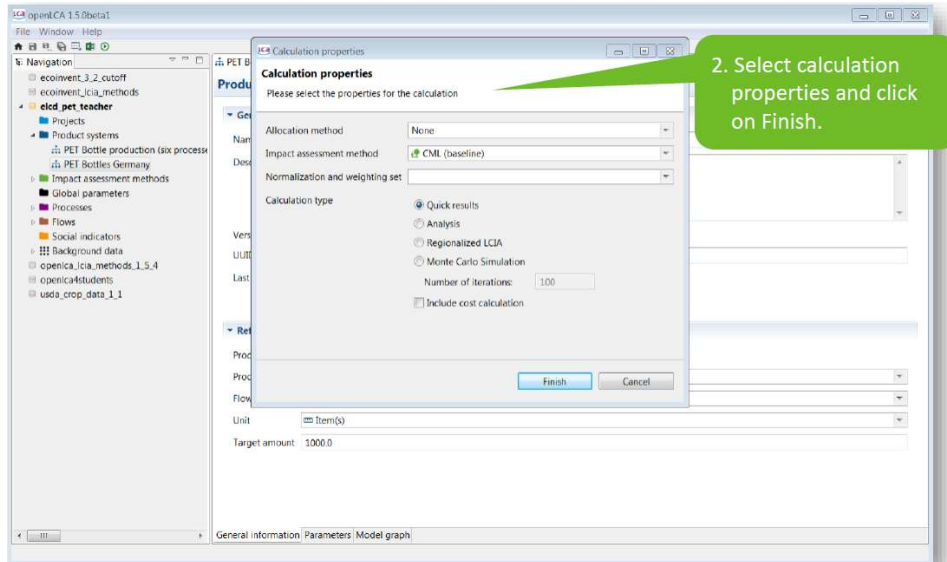
107

## Product system: Calculation

1. Click on "Calculate" in the General information tab.

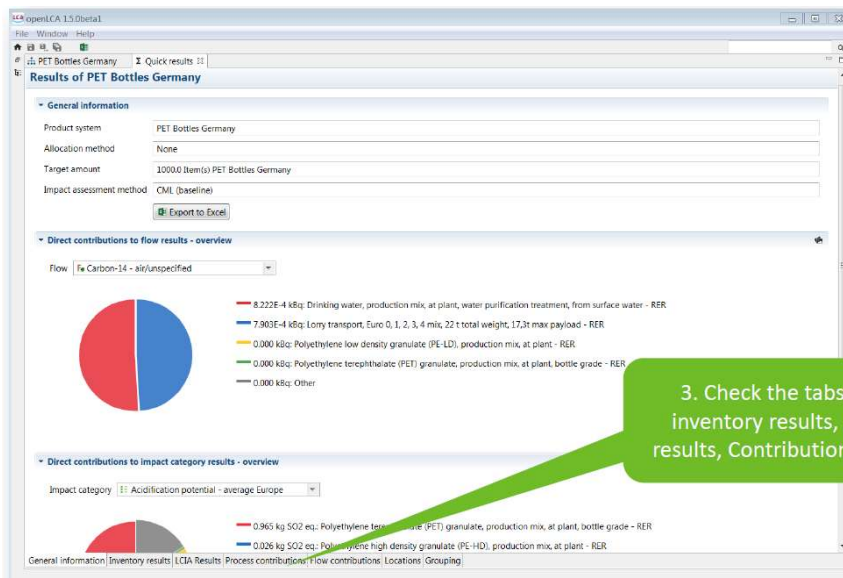
108

## Product system: Calculation (II)



109

## Product system: Calculation (III)



3. Check the tabs for inventory results, LCIA results, Contributions, etc.

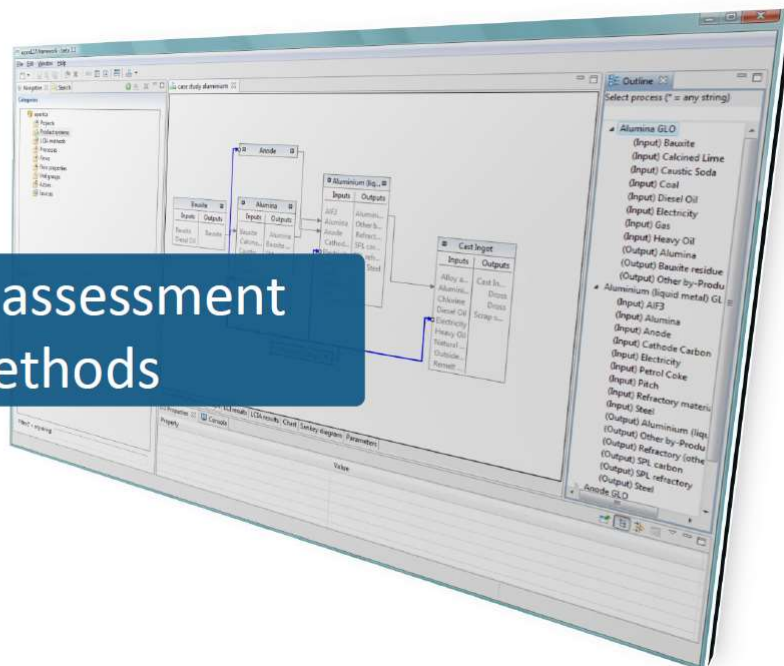
110

## Task #6: Creation of product system

- ◆ Create the product system called “PET full bottle” with reference product “PET full bottle”
  - ◆ Select “only link default providers”
  - ◆ Check the different views of the model graph. What can be observed in the graph?
  - ◆ Calculate the inventory of the product system
  - ◆ Which information can you derive from the inventory?

111

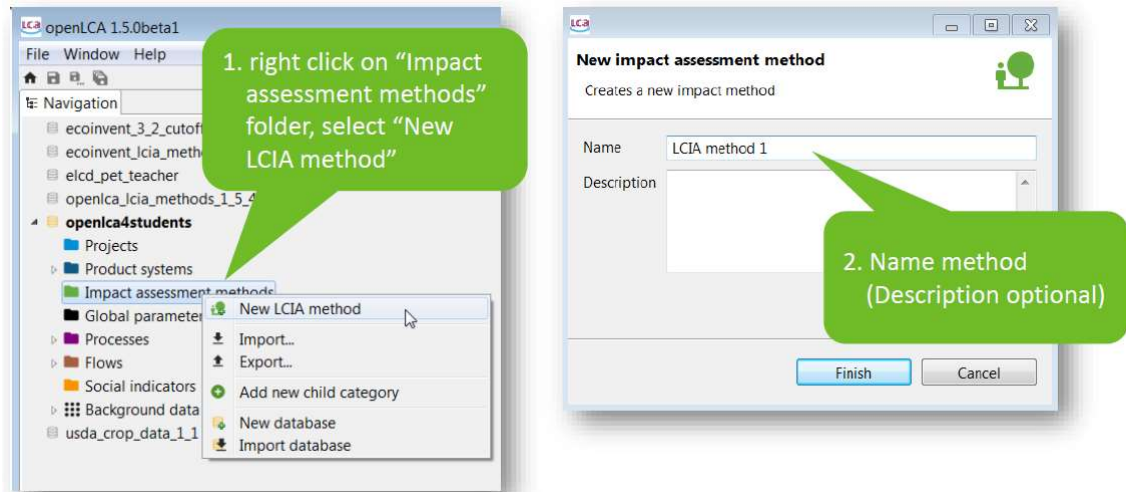
Impact assessment  
methods



112

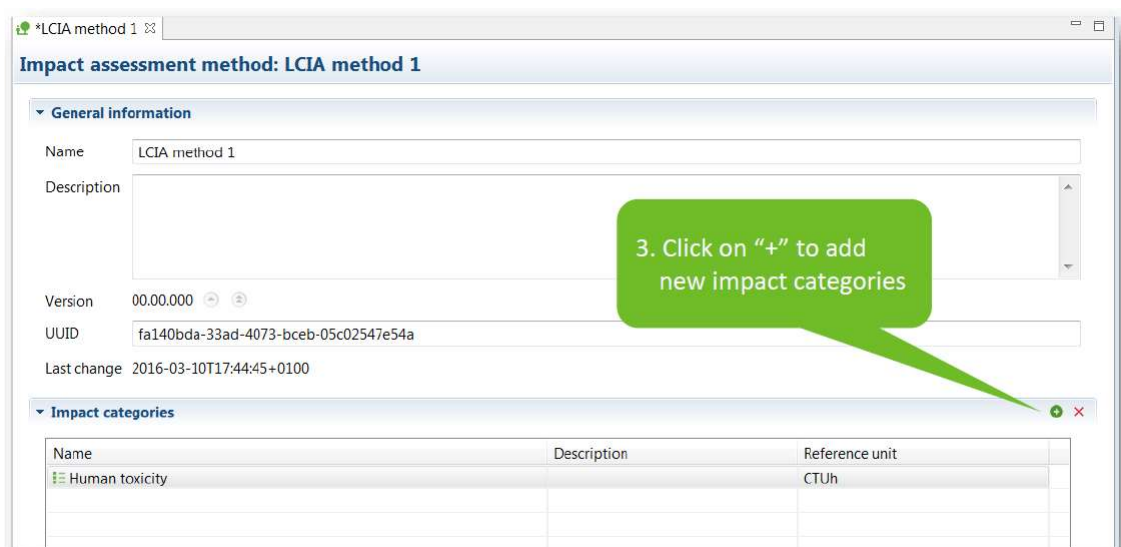


## Impact assessment method: Creation



113

## Impact assessment method: Creation (II)



114

## Impact assessment method: Creation (III)

Impact assessment method: LCIA method 1

Impact factors

Impact category: Human toxicity

Flow	Category	Flow property	Unit	Factor	Uncertainty

4. Click on "+" to add new characterisation factors

5. Select desired elementary flows

115

## Impact assessment method: Creation (IV)

Impact assessment method: LCIA method 1

Impact factors

Impact category: Human toxicity

Flow	Category	Flow property	Unit	Factor	Uncertainty
2-Methyl-1-propanol	air/high population density	Mass	DALY/kg	1.01	none

6. Add value for the factor (parameters can be used as in processes!)

Parameters

Global parameters

Input parameters

Name	Value	Uncertainty	Description	External source
p1	2.37E-7	none		

Dependent parameters

Name	Formula	Value	Description

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## Impact assessment method: Creation (V)

Impact assessment method: LCIA method 1

Normalization and weighting	Impact category	Normalization factor	Weighting factor
newSet	Human toxicity	-	-

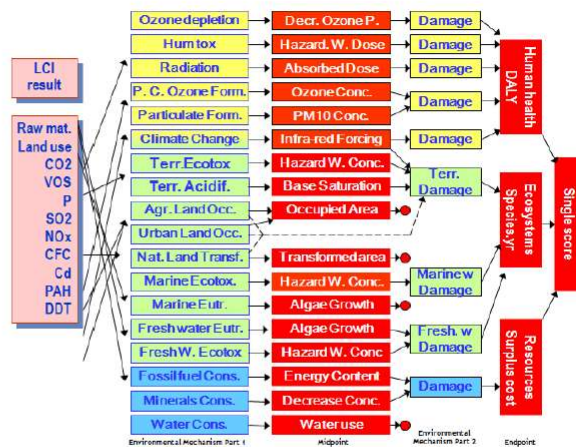
8. Click on the set name to automatically add the impact categories of the method

7. Click "+" to add new normalization/weighting set

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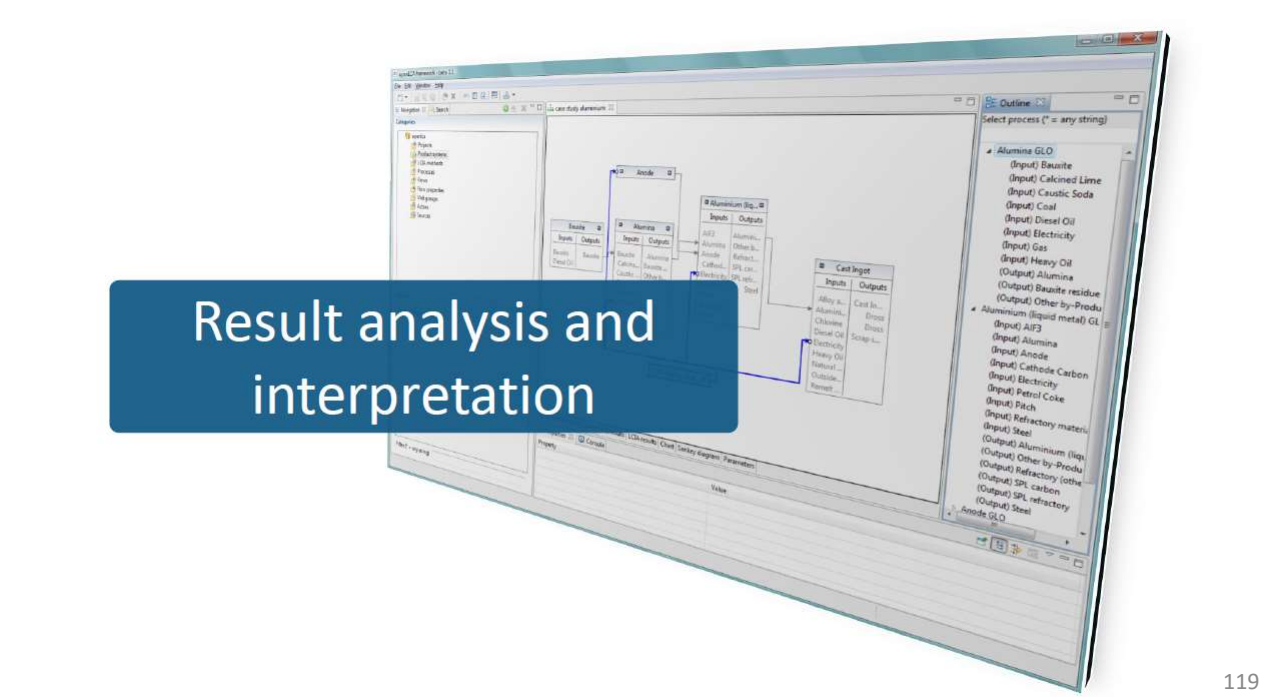
## LCIA methods

- LCIA methods convert inventory results into specific environmental impact categories (LCI results to associated environmental impacts, summarised in impact categories)
- CML baseline
- ReCiPe
- PEF (supposed to replace ILCD method)



Source: <http://www.lcia-recipe.net/project-definition>

118

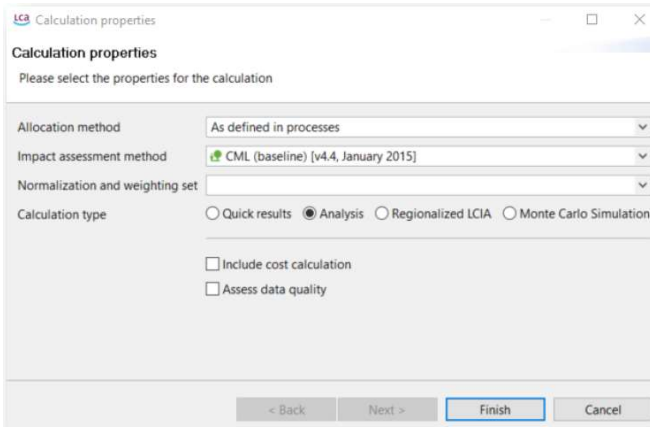


The screenshot shows a software interface for process simulation. On the left, there is a tree view of the process hierarchy. The main area displays a flow diagram with several process blocks connected by lines. On the right, there is a list of processes under the heading 'Outline'. A blue box with the text 'Result analysis and interpretation' is overlaid on the flow diagram.

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## Analysis functions

- ◆ To run the analysis functions the product system needs to be recalculated
- ◆ Click the calculation button in the General Information tab of the Product System, select an LCIA method and check "Analysis"



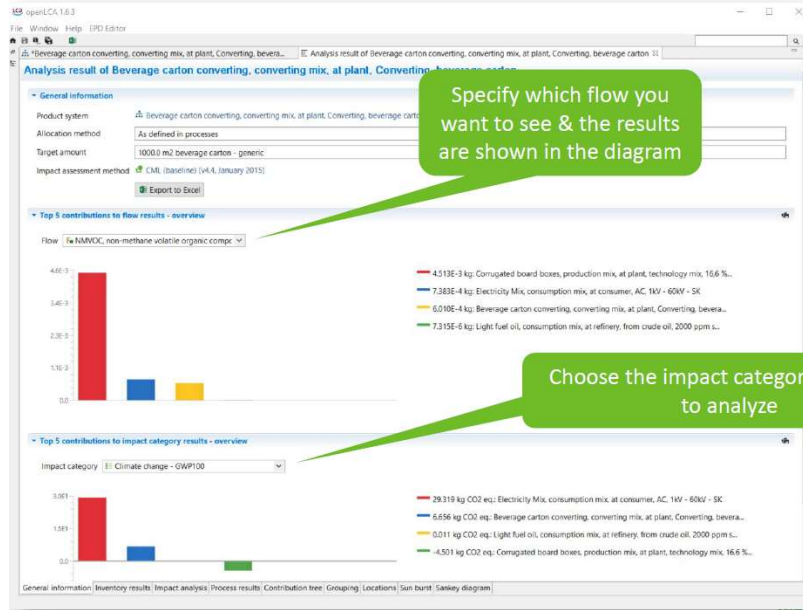
The screenshot shows the 'Calculation properties' dialog box. It contains the following settings:

- Allocation method: As defined in processes
- Impact assessment method: CML (baseline) [v4.4, January 2015]
- Normalization and weighting set: (empty)
- Calculation type:  Analysis,  Quick results,  Regionalized LCIA,  Monte Carlo Simulation
- Include cost calculation
- Assess data quality

At the bottom, there are buttons for '< Back', 'Next >', 'Finish', and 'Cancel'.

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## Analysis: Flow & Impact contributions



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## Analysis: Inventory Results

Inputs				
Name	Category	Sub-category	Amount	Unit
fa Aggregate, natural	Resource	in ground	0.40961	kg
fa Air	Resource	in air	136.63108	kg
fa Barite	Resource	in ground	0.02465	kg
fa Basalt, in ground	Resource	in ground	0.00745	kg
fa Basalt	Resource	in ground	0.00702	kg
fa biomass, 14.7 MJ/kg	Resource	biotic	0.00322	MJ
fa brown coal, 11.9 MJ/kg	Resource	in ground	76.43947	MJ
fa Calcium carbonate, in ground	Resource	in ground	0.17068	kg
fa Calcium chloride	Resource	in ground	1.43914E-11	kg

Outputs				
Name	Category	Sub-category	Amount	Unit
fa Acenaphthene	Emission to water	ocean	1.74028E-9	kg
Electricity Mix, consumption mix, at consumer, AC, 1W - 60W - SK	Energy carriers and technologies	Electricity	1.52002E-9	kg
Light fuel oil, consumption mix, at refinery, from crude oil, 2000 ppm sulphur	Energy carriers and technologies	Crude oil based fuels	3.09493E-10	kg
fa Acenaphthene	Emission to water	fresh water	7.52002E-11	kg
fa Acenaphthylene	Emission to water	ocean	6.63605E-10	kg
fa Acenaphthylene	Emission to water	fresh water	2.94395E-11	kg
fa Acetaldehyde	Emission to air	unspecified	6.64695E-6	kg
fa Acetic acid	Emission to water	ocean	4.64497E-9	kg
fa Acetic acid	Emission to air	unspecified	3.10332E-5	kg

Total requirements			
Process	Product	Amount	Unit
P Beverage carton converting, converting mix, at plant, Converting, beverage carton...	fa beverage carton - generic	1000.00000	m <sup>2</sup>
P Electricity Mix, consumption mix, at consumer, AC, 1W - 60W - SK	fa electricity mix	310.47000	MJ
P Dummy_LPG - liquefied petroleum gas	fa LPG - liquefied petroleum gas	15.48000	MJ
P Corrugated board boxes, production mix, at plant, technology mix, 16.6 % primary	fa corrugated board boxes	10.00000	kg
P Dummy_Waste paper	fa Waste paper	8.74000	kg
P Dummy_printing_ink	fa printing ink	1.70000	kg
P Dummy_polyethylene_low_density_foil(PE-LD)	fa polyethylene_low_density_foil(PE-LD)	0.60000	kg
P Light fuel oil, consumption mix, at refinery, from crude oil, 2000 ppm sulphur - EU...	fa light fuel oil	0.02000	kg

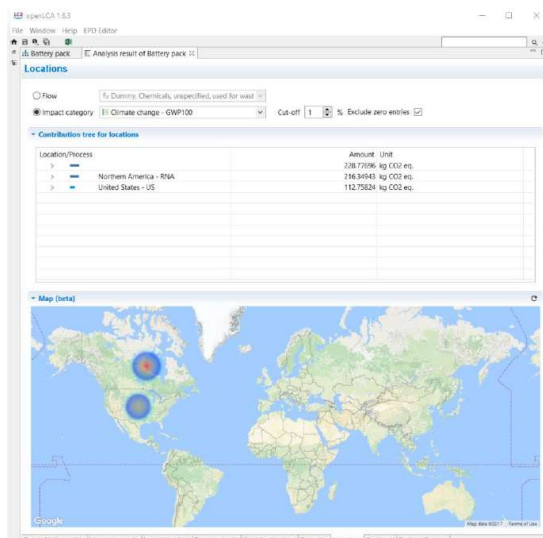
122

## Analysis: Impact Analysis (LCIA Results)

Name	Category	Inventory result	Impact factor	Impact result	Unit
Climate change - GWP100				31.48495	kg CO2 eq.
Electricity Mix, consumption mix, at consumer, AC, 10V - 60W - SX	Energy carriers and technolo...			25.31893	kg CO2 eq.
Carbon dioxide	Emission to air / unspecified	25.51618 kg	1.00000 kg CO2 eq./kg	25.51618	kg CO2 eq.
Methane	Emission to air / unspecified	0.11994 kg	25.00000 kg CO2 eq./kg	2.99855	kg CO2 eq.
Beverage carton converting, converting mix, at plant, Converting, be...	Systems / Packaging			6.65568	kg CO2 eq.
Congulated board boxes, production mix, at plant, technology mix, systems / packaging	Systems / Packaging			-4.50063	kg CO2 eq.
Acidification potential - average Europe				0.35911	kg SO2 eq.
Photochemical oxidation - high NOx				0.01769	kg ethylene eq.
Terrestrial ecotoxicity - ETP inf				0.06622	kg 1,4-dichlorobenzene eq.
Ozone layer depletion - ODP steady state				2.07100E-5	kg CFC-11 eq.
Depletion of abiotic resources - fossil fuels				513.37967	MJ
Human toxicity - HTP inf				3.83377	kg 1,4-dichlorobenzene eq.
Depletion of abiotic resources - elements, ultimate reserves				5.96327E-6	kg antimony eq.
Freshwater aquatic ecotoxicity - FAETP inf				0.20750	kg 1,4-dichlorobenzene eq.
Marine aquatic ecotoxicity - MAETP inf				2.63174E4	kg 1,4-dichlorobenzene eq.
Eutrophication - generic				0.01745	kg PO4--- eq.

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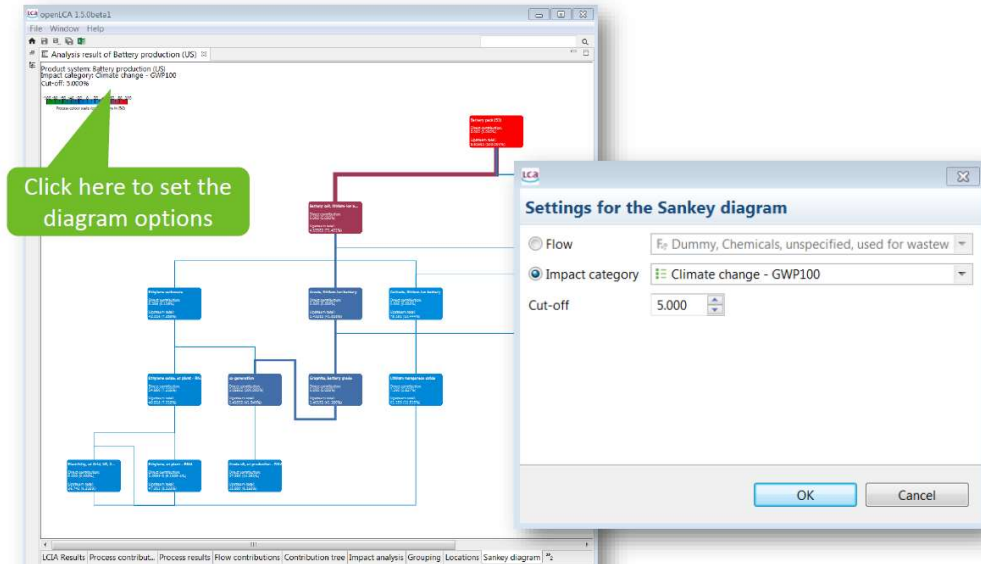
## Analysis: Locations



If you don't see any points in the map, click "reload"

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## Analysis: Sankey Diagram



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## Task #7: Calculation of impacts

- ◆ Calculate the environmental impacts caused by the production of 1 PET bottle filled with water using the LCIA method CML(baseline) and interpret the results.
  - ◆ Which process contribute most to the impact category “Global Warming Potential”?
  - ◆ Which is the direct contribution of the flow “Carbon dioxide” to the same impact category?
  - ◆ Do the raw materials contribute more than electricity to the final GWP value?
  - ◆ Where does the emissions of “VOC, volatile organic compounds” come from?

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The screenshot shows the openLCA software interface. A central window displays a process flow diagram for 'Cast Ingot', showing its inputs (Aluminum, Cathodic, Heavy Oil, Electricity, Pitch, Refractory material, Steel) and outputs (Cast Ingot, Dross, Scrap). To the right, an 'Outline' window lists various materials, including 'Alumina GLO' and 'Aluminium (liquid metal) GL'. A blue text box is overlaid on the diagram with the text 'Modeling the End-of-Life with openLCA'.

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## Modeling waste

- ◆ ISO 14044: “substances or objects which the older intends or is required to dispose of”
- ◆ By-products with no market value

Life Cycle Stage 2 - Processing / Manufacturing - Pulp and paper production (Inter...)	
Inputs	Outputs
Additives (paper production)	Bark
Electricity	Tall oil (raw product)
electricity	Virgin materials for paper production
Heat	Water (waste water, treated)
Packaging materials and cores	Water-turpentine mix
RER: integrated paper mill	Wood pellets (0% H2O content)
RER: Market pulp for paper production	Product: Water (waste water, treated)
thermal energy (MJ)	
Unspecified industrial waste treatment	
Water (process water)	
Wood for paper production	

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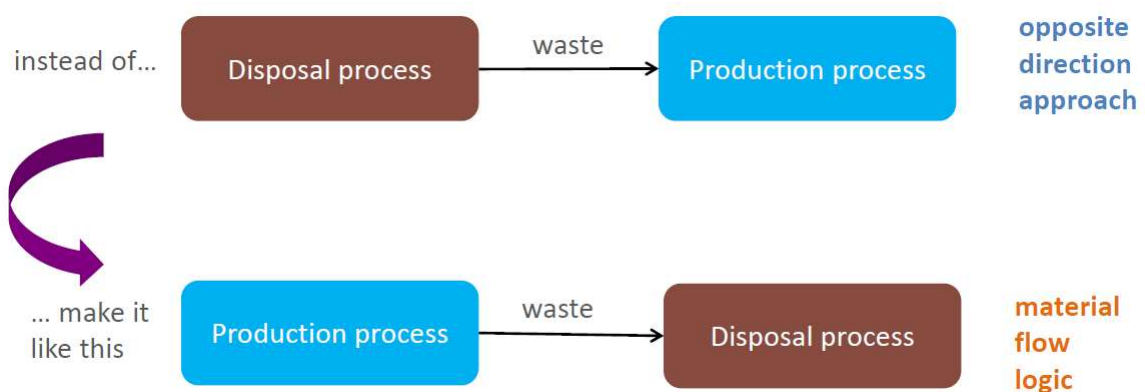


## Possible approaches

- ◆ Presently there are two possible approaches when modelling wastes and waste treatment:
- ◆ **opposite direction approach (ecoinvent)**
  - ◆ interpret the waste treatment as a service and add it as an input or add waste as a negative input, which mathematically means it is an output
- ◆ **material flow logic (openLCA)**
  - ◆ It follows the natural direction of the flow, where something is produced and the waste is an output from the production or use phase

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## Modeling of waste (II)



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## Waste treatment in ecoinvent

P Inputs/Outputs: yarn production, jute | yarn, jute | cut-off, U

### Inputs

Flow	Amount	Unit	Provider
F <sub>2</sub> jute fibre	1.16000	kg	P market for jute fibre   jute fibre   cut-off, U - GLO
F <sub>2</sub> spinning, bast fibre	1.16000	kg	P market for spinning, bast fibre   spinning, bast fibre   cut-off, U - GLO
F <sub>2</sub> waste graphical paper	-0.15588	kg	P market for waste graphical paper   waste graphical paper   cut-off, U - Europe without Switzerl..
F <sub>2</sub> waste graphical paper	-0.00412	kg	P market for waste graphical paper   waste graphical paper   cut-off, U - CH

### Outputs

Flow	Amount	Unit	Costs/Revenues	Uncertainty	Avoided prod...	Provider	Data quality e...	D
F <sub>2</sub> yarn, jute	1.00000	kg	0.71200 EUR	none				E

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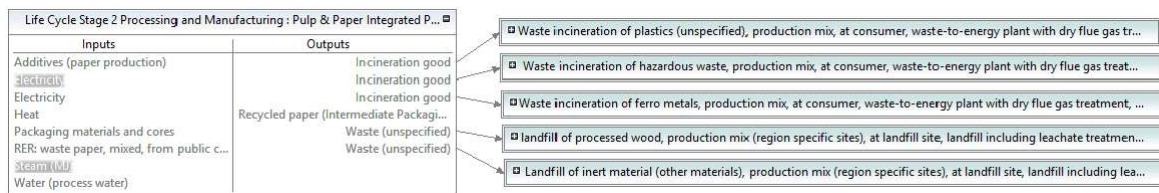
## Waste treatment modeling in openLCA

- ◆ openLCA can handle both ways of modelling waste but it is necessary to pay attention to the flows used
- ◆ Product flows:
  - ◆ on the input side are considered input materials
  - ◆ on the output side are considered by products and can be allocated or marked as avoided product
- ◆ Waste flows:
  - ◆ On the output side are considered waste and can be connected to the waste treatment process
  - ◆ On the input side are the raw material for a waste treatment process and do not allow a connection with a provider

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## Material flow logic

- ◆ When you select the waste flow type, openLCA recognizes it and allow you to specify default providers for them on the output side of your process
- ◆ This means that this flow will be treated in the following process



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## Waste treatment flows in openLCA

- ◆ The waste flows are marked with the symbol of a brush
- ◆ One can create them normally using the flow editor

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## Waste treatment modeling in openLCA

▼ Inputs

Flow	Category	Amount	Unit	Costs/Revenues	Uncertainty	Avoided waste	Provider
F <sub>2</sub> Additives (paper production)	Valuable substances/Intermedi...	44.50535	kg		none		P Life Cy
F <sub>2</sub> Electricity	Energy carriers and technologi...	413.15446	MJ		none		P Electric
F <sub>2</sub> Heat	Energy carrier/Thermal energy	7347.37000	MJ		none		P CRED(I)
F <sub>2</sub> Packaging materials and cores	Materials/Packaging	2.43062	kg		none		P Life Cy
F <sub>2</sub> RER: waste paper, mixed, from public co...	Materials production/Paper an...	1075.28408	kg		none		P Life Cy
F <sub>2</sub> Water (process water)	Materials/Operating materials	5951.39022	kg		none		P Life Cy

▼ Outputs

Flow	Amount	Unit	A.	Provider	Description
F <sub>2</sub> Incineration good	32.90000	kg		P Waste incineration of plastics (unspecified), pro...	incineration of plastics (PE, PS, PP, PB)
F <sub>2</sub> Incineration good	1.20000	kg		P Waste incineration of hazardous waste, producti...	disposal of bilge oil to hazardous waste incineration
F <sub>2</sub> Incineration good	11.00000	kg		P Waste incineration of ferro metals, production ...	steel to incineration
F <sub>2</sub> Recycled paper (Intermediate Packaging)	1000.00000	kg			Functional Unit 1 tonn paper
F <sub>2</sub> Steam (MJ)	107.00000	MJ	✓	P Process steam from biomass (solid) 90%, produ...	
F <sub>2</sub> Electricity	393.00000	MJ	✓	P Electricity grid mix 1kV-60kV , consumption mib...	

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## Waste treatment processes in openLCA

▶ Inputs/Outputs: treatment of waste expanded polystyrene, municipal incineration | waste expanded polystyrene | Cutoff, U

▼ Inputs							
Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided waste	Provider
F <sub>1</sub> ammonia, anhydrous, liquid	201.Manufacture of basic c...	9.74000E-5	kg		lognormal: g...		P market for...
F <sub>1</sub> cement, unspecified	239.Manufacture of non-m...	0.00487	kg		lognormal: g...		P market for...
F <sub>1</sub> chemical, inorganic	201.Manufacture of basic c...	4.45000E-6	kg		lognormal: g...		P market for...
F <sub>1</sub> chemical, organic	C.Manufacturing/201.Manufa...	9.41000E-5	kg		lognormal: g...		P market for...
F <sub>1</sub> chromium oxide, flakes	201.Manufacture of basic c...	5.69000E-8	kg		lognormal: g...		P market for...
F <sub>1</sub> heat, district or industrial, natural gas	351.Electric power generati...	0.00855	MJ		lognormal: g...		P market for...
F <sub>1</sub> hydrochloric acid, without water, in ...	201.Manufacture of basic c...	2.67000E-6	kg		lognormal: g...		P market for...
F <sub>1</sub> iron (III) chloride, without water, in 4...	201.Manufacture of basic c...	0.00011	kg		lognormal: g...		P market for...
F <sub>1</sub> municipal waste incineration facility	429.Construction of other ci...	2.50000E-10	Item(s)		lognormal: g...		P municipal ...
F <sub>1</sub> process-specific burdens, municipal ...	382.Waste treatment and di...	1.00000	kg		lognormal: g...		P process-s...
F <sub>1</sub> process-specific burdens, residual m...	382.Waste treatment and di...	0.01220	kg		lognormal: g...		P process-s...
F <sub>1</sub> process-specific burdens, slag landfill	382.Waste treatment and di...	0.01100	kg		lognormal: g...		P process-s...
F <sub>1</sub> quicklime, milled, packed	239.Manufacture of non-m...	0.00020	kg		lognormal: g...		P market for...
F <sub>1</sub> residual material landfill	429.Construction of other ci...	2.54000E-11	Item(s)		lognormal: g...		P residual m...
F <sub>1</sub> slag landfill	429.Construction of other ci...	3.03000E-11	Item(s)		lognormal: g...		P slag landf...
F <sub>1</sub> sodium hydroxide, without water, in ...	201.Manufacture of basic c...	0.00035	kg		lognormal: g...		P market for...
F <sub>1</sub> titanium dioxide	201.Manufacture of basic c...	2.79000E-6	kg		lognormal: g...		P market for...
F <sub>1</sub> waste expanded polystyrene	382.Waste treatment and...	1.00000	kg		none		

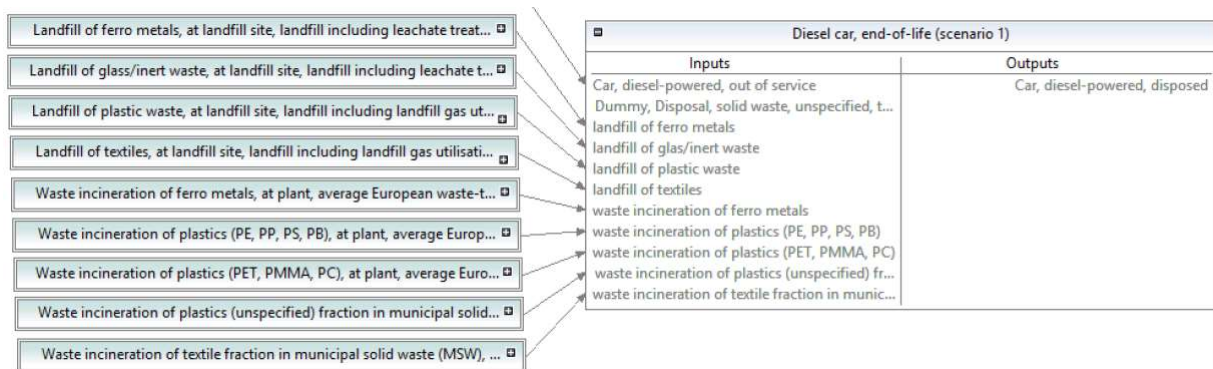
  

▼ Outputs							
Flow	Category	Amount	Unit	Costs/Revenu...	Uncertainty	Avoided pro...	Provider
F <sub>2</sub> Aluminium	Emission to air/high popula...	3.01000E-7	kg		lognormal: g...		
F <sub>2</sub> Aluminium	Emission to water/surface ...	0.00014	kg		lognormal: g...		
F <sub>2</sub> Aluminium	Emission to water/surface ...	1.60000E-8	kg		lognormal: g...		
F <sub>2</sub> Ammonia	Emission to air/high popula...	1.53000E-4	kg		lognormal: g...		
F <sub>2</sub> Antimony	Emission to air/high popula...	1.61000E-13	kg		lognormal: g...		
F <sub>2</sub> Antimony	Emission to water/surface ...	2.65000E-5	kg		lognormal: g...		
F <sub>2</sub> Antimony	Emission to water/surface ...	1.44000E-5	kg		lognormal: g...		
F <sub>2</sub> Arsenic	Emission to air/high popula...	1.07000E-14	kg		lognormal: g...		
F <sub>2</sub> Arsenic, ion	Emission to water/surface ...	1.01000E-6	kg		lognormal: g...		
F <sub>2</sub> Arsenic, ion	Emission to water/surface ...	8.23000E-7	kg		lognormal: g...		
F <sub>2</sub> Barium	Emission to air/high popula...	1.80000E-7	kg		lognormal: g...		
F <sub>2</sub> Barium	Emission to water/surface ...	0.00016	kg		lognormal: g...		
F <sub>2</sub> Barium	Emission to water/surface ...	2.47000E-8	kg		lognormal: g...		
F <sub>2</sub> Beryllium	Emission to air/high popula...	4.82000E-10	kg		lognormal: g...		
F <sub>2</sub> Beryllium	Emission to water/surface ...	3.88000E-7	kg		lognormal: g...		
F <sub>2</sub> Beryllium	Emission to water/surface ...	2.99000E-10	kg		lognormal: g...		
F <sub>2</sub> BOD5, Biological Oxygen Demand	Emission to water/surface ...	0.00697	kg		lognormal: g...		
F <sub>2</sub> BOD5, Biological Oxygen Demand	Emission to water/surface ...	3.23000E-5	kg		lognormal: g...		
F <sub>2</sub> Bromine	Emission to air/high popula...	2.01000E-5	kg		lognormal: g...		

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## Opposite direction approach

- ◆ The waste is modeled using a product flow at the input side with a negative amount depending on whether the approach used was the 2<sup>nd</sup> or 3<sup>rd</sup> version of ecoinvent
- ◆ A default provider of waste treatment can be set



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## Task #8: model the EoL with the two approaches

- ◆ To model the use phase, create a process called “PET full bottle, transported” and add a transport of 50km by lorry to the shop.
- ◆ Create two copies of “Waste incineration of plastics (PET, PMMA, PC), at plant, average European waste-to-energy plant, without collection, transport and pre-treatment” within the folder of your processes (use copy/paste). Before doing that, check that the input of the process is 1 kg of plastic.
  - ◆ Rename the two process “Waste incineration of plastics (Material Flow)” and “Waste incineration of plastics (Opposite Direction)”
  - ◆ Which approach is adopted in this process by default?

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## Task #8: model the EoL with the two approaches (II)

- ◆ Opposite direction approach
  - ◆ Create a process called “PET bottle EoL (OD)” with a new mass reference flow called “PET bottle used”
  - ◆ Add the transported bottle and the treatment process as a negative service in input. Pay attention to the mass involved!
  
- ◆ Material Flow logic
  - ◆ Create a new mass-based waste flow called “PET bottle used, waste”
  - ◆ Add the new flow as an input for “Waste incineration of plastics (Material Flow)”, set this new flow as reference flow (right click) and remove the previous reference output. Is the mass correct? (Yes, it is. You removed 1 kg from output, adding 1 kg to input)
  - ◆ Create a process called “PET bottle EoL (MF)” with the flow “PET bottle used” as reference flow. Use the correct amount
  - ◆ Add the transported bottle in input and the treatment process as a positive output. Pay attention to the mass involved!
  
- ◆ Now, check the model graph! Is it different?

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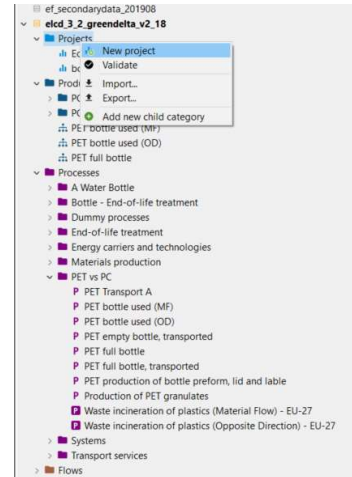


Projects

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## Projects: Creation

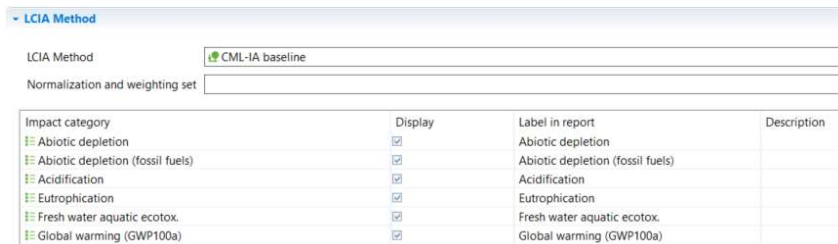
- ◆ Projects are created to compare different product systems
- ◆ To create a new project, right-click on Projects and select “new”



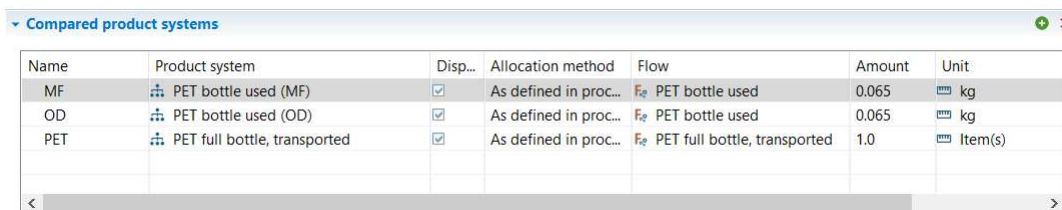
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## Projects: Creation (II)

- ◆ Select the LCIA methodology to perform the comparison



- ◆ Add the product systems to be compared and specify the quantity for each one



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## Projects: Creation (III)

- ◆ It is possible to specify the values of any parameter used in the product systems


Parameters					
Parameter	Context	Label in report	Description	MF	OD

- ◆ If specifies, any contributions of the selected processes in the project setup to the variant results of the selected LCIA category will be shown

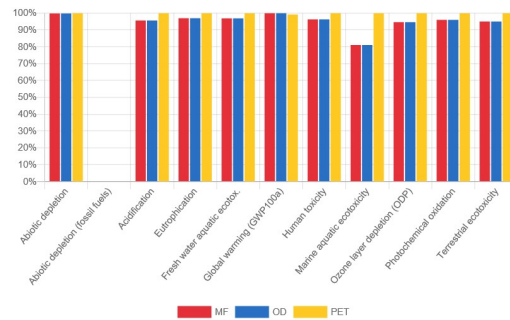
Process contributions		
Process	Label in report	Description
P PET full bottle	PET full bottle	

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## Projects: Report

- ◆ The comparison will be performed clicking on the “Report” button 
- ◆ The report sections can be modified before calculation on the dedicated tab at the bottom of the screen
- ◆ The results will be shown in terms of tables and graphs

Indicator	MF	OD	PET	Unit
Abiotic depletion	4.40991e-9	4.40991e-9	4.42033e-9	kg Sb eq
Abiotic depletion (fossil fuels)	0	0	0	MJ
Acidification	1.51223e-2	1.51223e-2	1.58239e-2	kg SO2 eq
Eutrophication	1.03368e-3	1.03368e-3	1.06648e-3	kg PO4--- eq
Fresh water aquatic ecotox.	4.87685e-3	4.87685e-3	5.03611e-3	kg 1,4-DB eq
Global warming (GWP100a)	3.44847e+0	3.44847e+0	3.42001e+0	kg CO2 eq
Human toxicity	2.79593e-1	2.79593e-1	2.90501e-1	kg 1,4-DB eq
Marine aquatic ecotoxicity	3.23604e+2	3.23604e+2	3.99503e+2	kg 1,4-DB eq
Ozone layer depletion (ODP)	1.83928e-7	1.83928e-7	1.94477e-7	kg CFC-11 eq
Photochemical oxidation	8.47388e-4	8.47388e-4	8.83074e-4	kg C2H4 eq
Terrestrial ecotoxicity	1.33859e-3	1.33859e-3	1.40919e-3	kg 1,4-DB eq



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## Task #9: Create a project

- ◆ Create a project and compare the two product systems modelled using different approaches.
- ◆ If they are not equal, something is wrong!!

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Sensitivity analysis

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## Sensitivity analysis

- ◆ “systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a study” (ISO 14040)
  
- ◆ Are results stable if you change specific aspects?
  - ◆ What happens if you expand your system boundaries?
  - ◆ What happens if you use other allocation methods?
  - ◆ What happens if you change your assumptions?

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## Modeling with parameters

- ◆ Useful for sensitivity analyses → What impact does one aspect have when I change its value?
- ◆ Useful for preliminary data: data can be changed easily at the end of your study
- ◆ Create different versions of your life cycle by changing the input values
- ◆ Enter calculation rules instead of concrete values → more flexibility
  
- ◆ Available on process, product system, LCIA method, project and database level
- ◆ Local and global parameters → parameters can overwrite each other!
- ◆ Parameters can be linked to other parameters (i.e. dependent parameters) → Loops are not allowed

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## Process: parameters

The screenshot shows the 'Parameters' window in the openCA 1.5.0beta1 software. The window title is 'P ammonium bicarbonate production | ammonium bicarbonate | cut-off, U - RER :'. The left sidebar shows a navigation tree with categories like 'Projects', 'Product systems', 'Impact assessment methods', 'Global parameters', 'Processes', 'Flows', 'Social indicators', 'Background data', 'Flow properties', 'Unit groups', 'Currencies', 'Sources', 'Actors', 'Locations', 'ecoinvent\_lca\_methods', 'elcrl\_3\_1\_greenedelta\_v2', 'elcrl\_pet\_teacher', 'openca\_lca\_methods\_1\_5\_4', 'openca4students', 'openca4teacher', and 'usda\_crop\_data\_1\_1'. The main area contains three tables: 'Global parameters', 'Input parameters', and 'Dependent parameters'. The 'Input parameters' table has columns for Name, Value, Uncertainty, and Description. The 'Dependent parameters' table has columns for Name, Formula, Value, and Description. The 'Parameters' tab in the bottom navigation bar is circled in red.

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## Process: parameters

The screenshot shows the 'Parameters: PET production of bottle preform, lid and lable' window. The 'Input parameters' table has one row:
 

Name	Value	Uncertainty	Description
peso_bot	0.065	none	

 The 'Inputs' table has two rows:
 

Flow	Category	Amount	Unit	Costs/Re...	Uncertal...	Avoided ...	Provider	Data qua...	Descrip...
Electricity	Energy carriers and ...	1.00000	MJ		none		Electrici...		
PET granulates, transported			kg		none		PET Tr...		

 Two curved arrows point from the 'Inputs' table back to the 'Input parameters' table, indicating a data flow or dependency.

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## Process: parameters at Global and Local level

- ◆ Global parameters can be used by any process
- ◆ Local parameters are process-specific and overwrites global parameters values.
  - ◆ Try to use different names to avoid confusion

The screenshot shows a software interface with a process tree on the left and a parameter configuration window on the right. The process tree includes 'PET vs PC' and 'PET production of bottle preform, lid and label'. The parameter window is titled 'Parameters: PET production of bottle preform, lid and label' and contains two tables: 'Global parameters' and 'Input parameters'.

Name	Value	Uncertainty	Description
Massa_totale	65.0	none	
numero_bottiglie	1000.0	none	
Peso_bottiglia	0.065	none	

Name	Value	Uncertainty	Description
peso_bot	0.065	none	

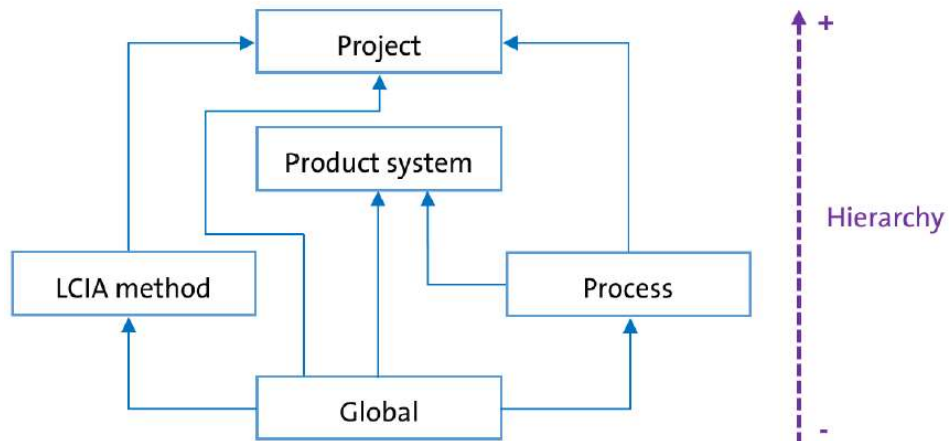
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## Parameter rules

- ◆ Parameter names...
  - ◆ ... must be one word, underscores are allowed.
  - ◆ ... cannot contain special characters.
  - ◆ ... cannot have more than 255 characters.
- ◆ Parameter formulas...
  - ◆ ... can contain single values, simple equations, or complex functions including logical expressions.
  - ◆ ... do not contain units, so please add them in the comment field.
  - ◆ ... cannot have more than 255 characters.
- ◆ The amount of parameters is, theoretically, not limited.
- ◆ Use point (.) instead of comma (,) for the decimal numbers.

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## Parameters: Hierarchy



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## Parameter: checking formulas

- ◆ For complex formulas you must use a certain format (e.g. Tan (a), trunc(c), etc.). Use the formula interpreter to find errors.

Select "Formula Interpreter" in "Window" menu

```

openLCA 1.6.3
File Window Help EPD Editor
Show views >
Developer tools >
Bulk-replace >
Formula interpreter
The open
For mode
Licenced
Created a

Console
Formula interpreter
openLCA Formula Interpreter
type 'help' to display the help message

olca<< help
evaluate an expression:      type in the expression and press enter, e.g. sin(42)
define a variable:          type var <variable name> = <expression>, e.g. var a = sin(42)
exit the interpreter:       type 'exit' or 'quit' and press enter
olca<<
  
```

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## Product system: Parameters

1. Click here to add parameters from processes used in the product system

2. Select the parameters you want to modify

Parameter	Amount	Uncertainty
Barge, technology mix, 1.228 t pay load capacity - GLO		
Plane, technology mix, cargo, 68 t payload - GLO		

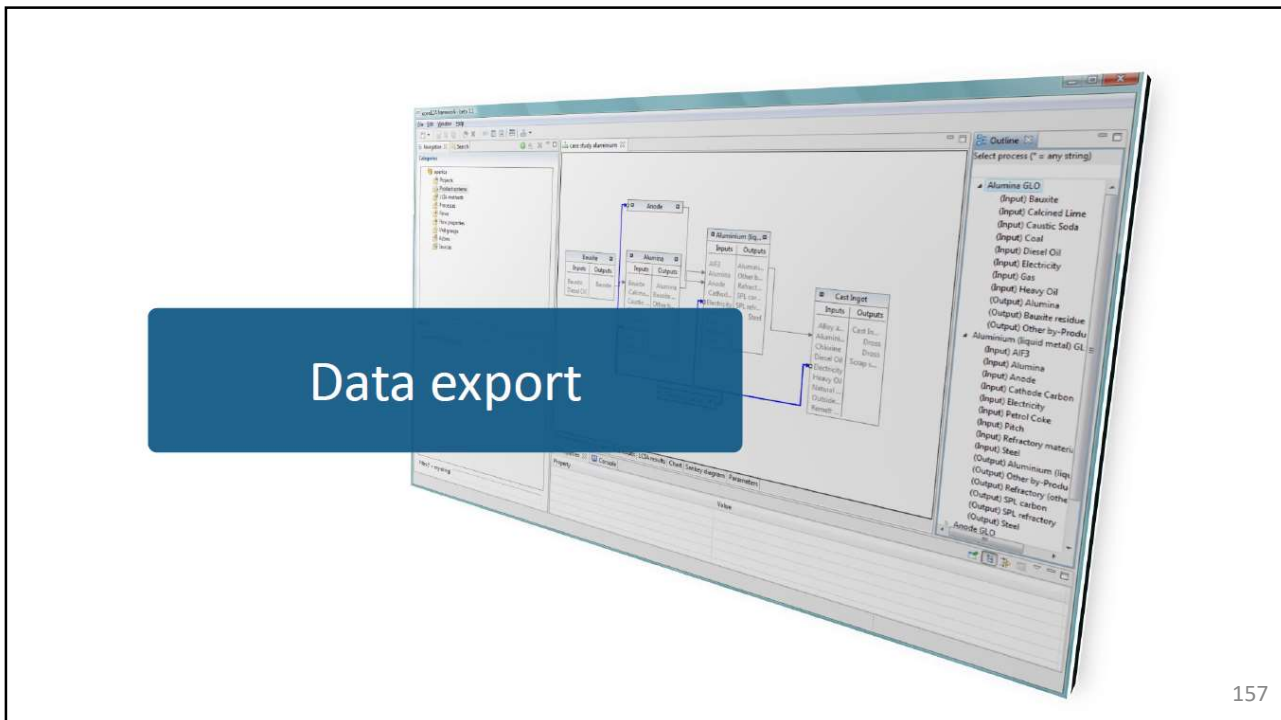
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## Product system: Parameters (II)

3. Change the values as desired; the new value will only affect the specified process

Context	Parameter	Amount	Uncertainty
Barge, technology mix, 1.228 t ...	Distanz	200	none

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## EcoSpold export

### EcoSpold 1

- Processes
- Impact assessment methods

### EcoSpold 2

- Processes

## ILCD export

- Actors
- Flow properties
- Flows
- LCIA methods
- Processes
- Product systems
- Sources
- Unit groups

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## Excel export

- Processes
- Quick results
- Analysis results
- Monte Carlo simulation results
- Product systems:
  - Elementary flows
  - Product flows
  - LCIA factors

## Other export formats

### JSON-LD

- Every element in an openLCA database

### CSV-Matrix

- Graph of a product system

### Images

- Diagrams

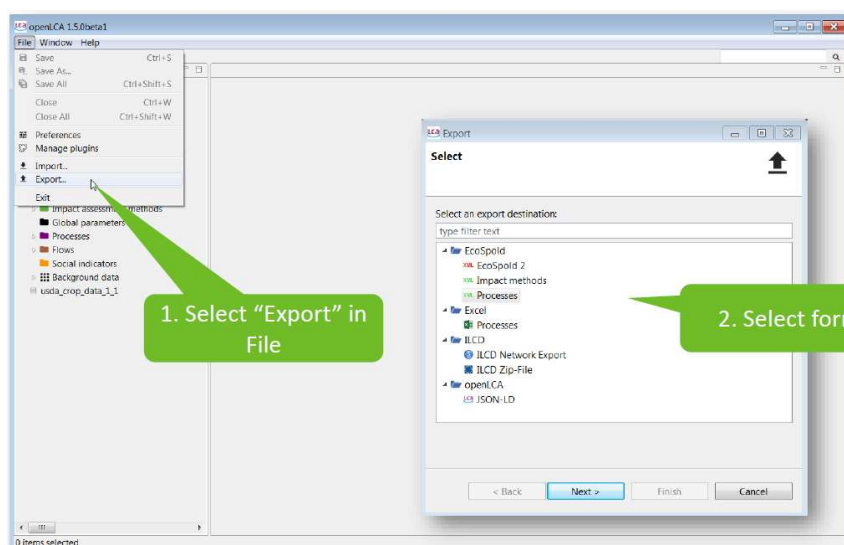
### HTML

- Project report

### openLCA script (.zolca)

- Complete databases

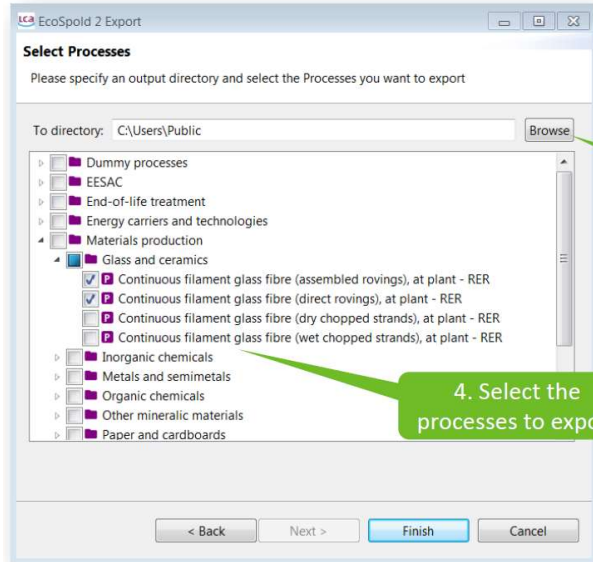
## Process export



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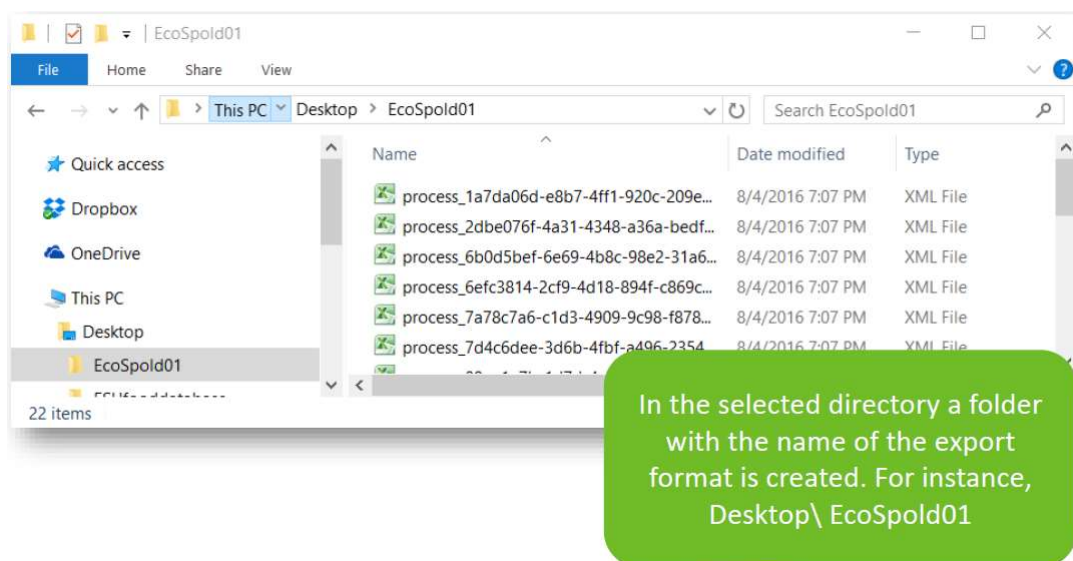


## Process export (II)



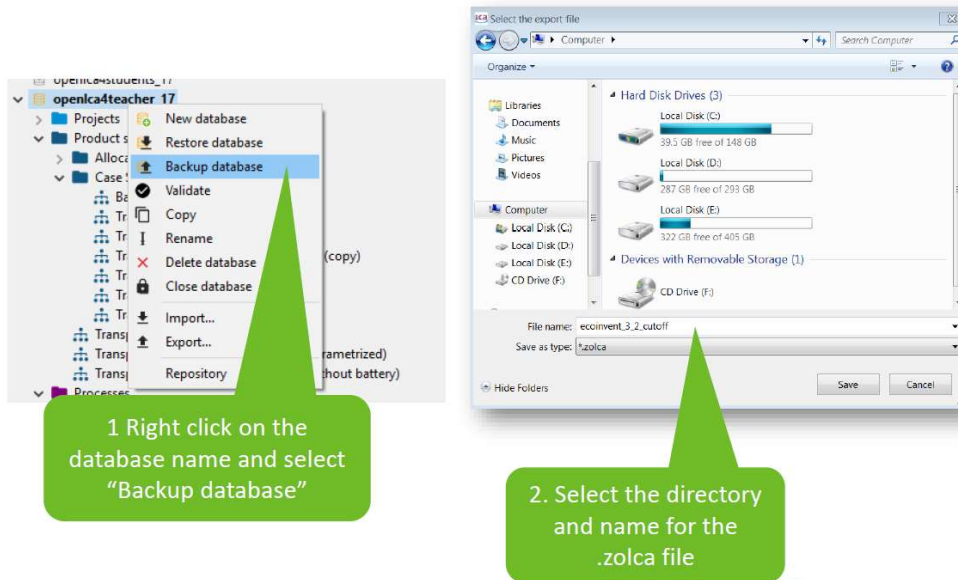
161

## Process export (III)



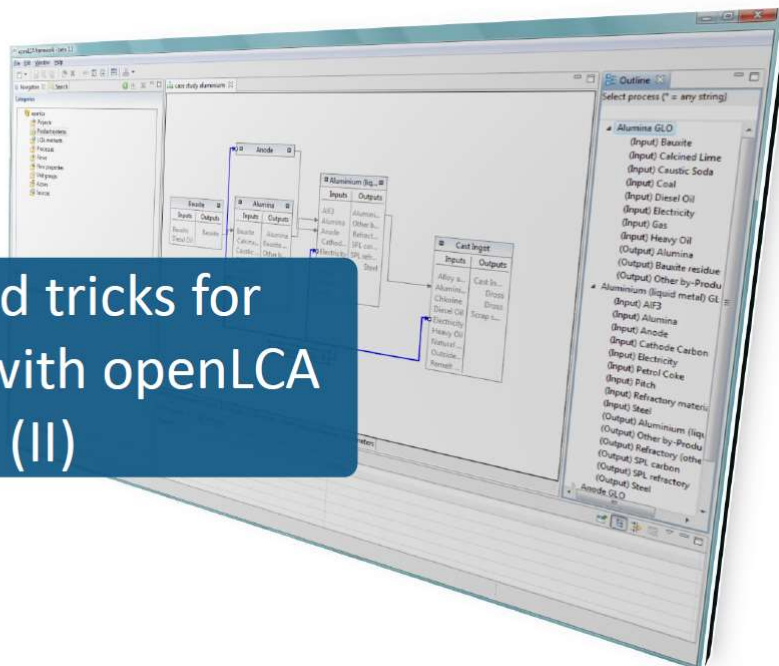
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## Export openLCA database



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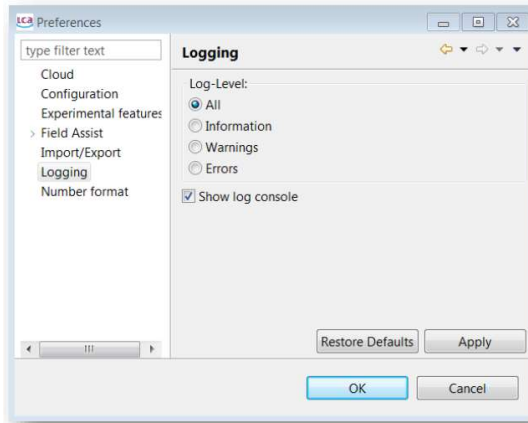
## Tips and tricks for working with openLCA (II)



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## Errors

- ◆ It is possible to report all errors in a log file automatically
- ◆ To do so go to file/preferences/logging and check "All"

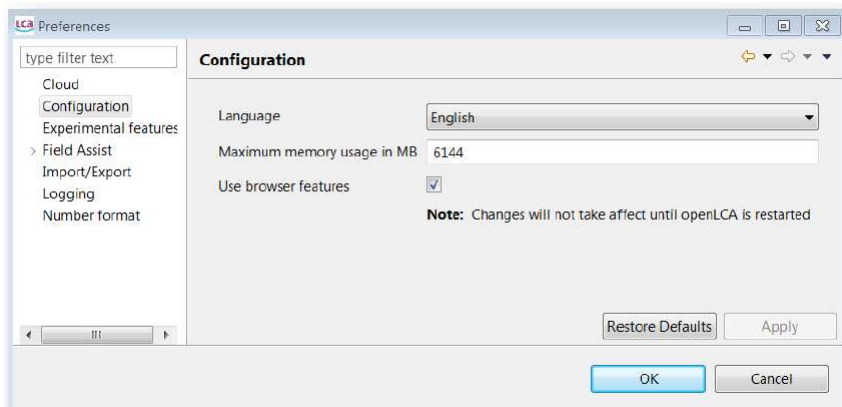


The log file is rewritten every time openLCA is restarted!

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## Language

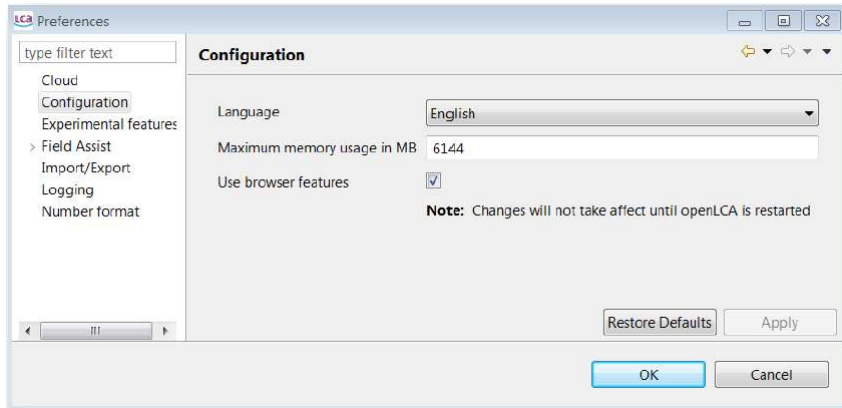
- ◆ openLCA is available in Arabic, Bulgarian, Catalan, Chinese, English, French, German, Italian, Portuguese, Spanish and Turkish
- ◆ Change it under File/Preferences/Configuration.
- ◆ Once you change the language, restart the program to activate it



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## Memory usage

- ◆ Some databases required higher memory usage (e.g., ecoinvent 3) for the calculations
- ◆ Change it under File/Preferences/Configuration.



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## openLCA-data directory

- ◆ The openLCA data folder is automatically created in your user/Documents folder
- ◆ The directory can be edited in the 'openLCA.ini' file contained in the openLCA folder with a text editor in the following way:

```
-clean
-nl
en
-data
@noDefault
-olcaDataDir
HERE THE FULL PATH OF THE NEW DIRECTORY
-olcaVersion
1.4.0
-vmargs
-Xmx4096M
-Dorg.openlca.core.updateSite=http://nexus.openlca.org/updatesite
```

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## Task #10: Create the PC bottle

- ◆ Create a new bottle made of PC and compare it with the PET bottle using a new Project
- ◆ Everything will be the same, except for the raw materials. They will be:
  - ◆ Polycarbonate granulate (PC): 60g
  - ◆ Polyethylene low density granulate (PE-LD): 4g
  - ◆ Polybutadiene granulate (PB): 1g