GreenDelta
sustainability consulting + software

openLCA

openLCA Advanced Training

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GreenDelta GmbH

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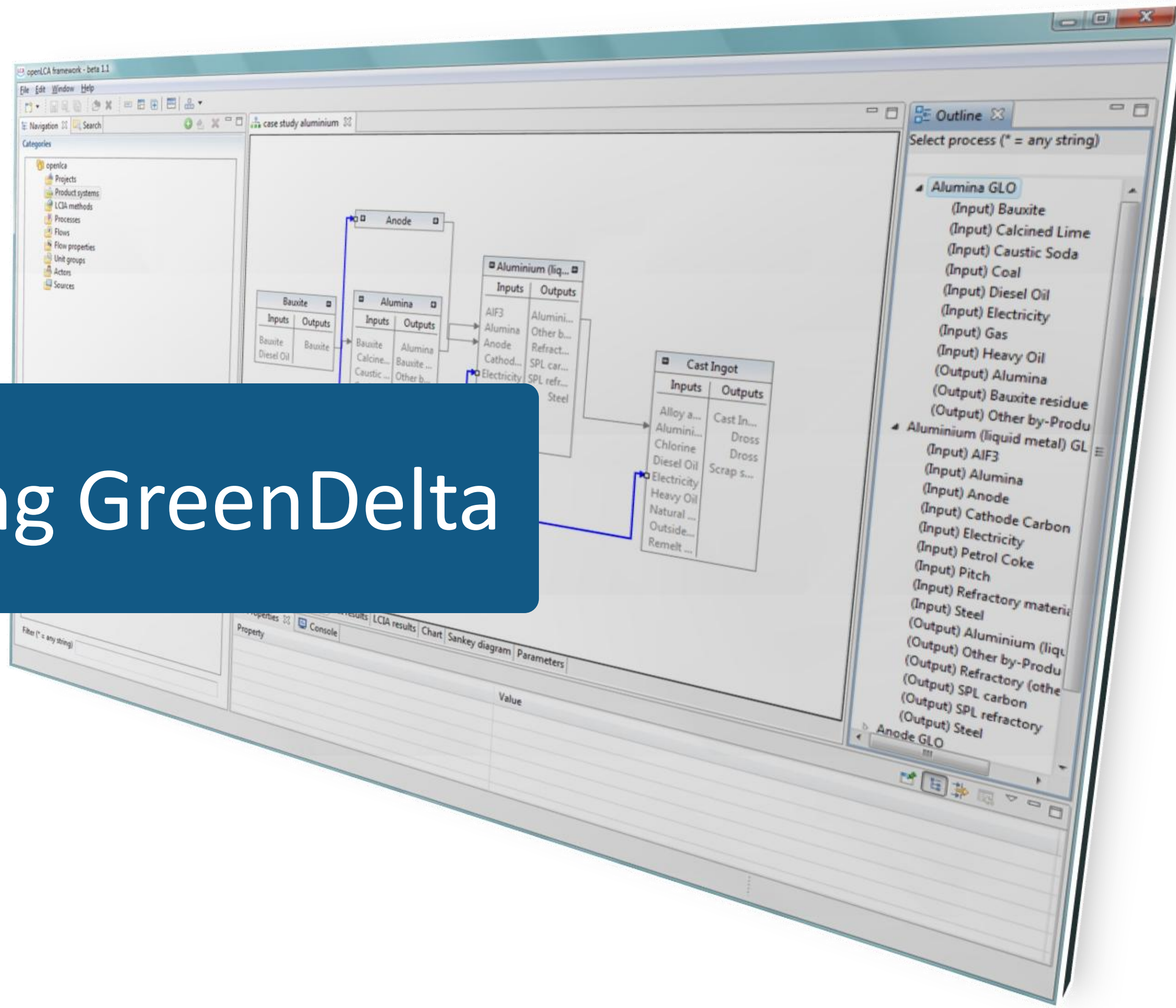
Introducing GreenDelta



GreenDelta background

- Founded by Dr. Andreas Ciroth in 2004
- 10 employees (engineers, biologists, IT-Specialists, business administrators)
- Office in Berlin
- Business world-wide: sustainability research, life cycle assessments, databases, software for life cycle assessments and sustainability

GreenDelta, What we do

- (environmental) LCA: case studies, critical reviews, data collection, creating databases
- Social LCA : social impacts of products throughout their entire life cycle
- Life Cycle Costing: costs of products throughout their entire life cycle

GreenDelta, What we do (II)

- Software development:
  - openLCA: worldwide leading open source LCA software; the only professional software of its kind
  - openLCA Web Enterprise: web-based openLCA software, originally developed for BASF
  - E-DEA: Software for Eco-Design, connects with SimaPro
  - various LCA hubs (CAP'EM, Copper EPD Chile, ...)

GreenDelta, What we do (III)

- Software and data sales:
  - SimaPro Center for Germany
  - database sales for ecoinvent, GaBi, Social Hot Spots Database, ...
  - openLCA Nexus: largest consistent collection of sustainability and LCA data worldwide

GreenDelta for openLCA

- Software expansion/adaptation
- Case studies
- Guided case studies
- Data acquisition
- Database compilation

GreenDelta for openLCA (II)

- Crititcal review (ISO 14040)
- LCA, LCC, SLCA
- Data management and hosting
- openCLA Training
- Service und Support

GreenDelta Project examples

- Laptop study: Life cycle assessment and social LCA for a notebook, carried out for Podde in 2011

- Life cycle assessment of satellite systems, carried out for the European Space Agency in 2013

- PROSUITE EU 7th FP research project 2009-2013, GreenDelta develops a sustainability assessment software based on openLCA for prospective technology assessment

- Nano3bio EU 7th FP research project, 2013-, GreenDelta's contribution: modeling the LCA for chitosans

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GreenDelta Project examples (II)

- EPD Editor: Development of a tool ("EPD Editor") for creating Environmental Product Declarations in openLCA, funded by the German Federal Institute for Research on Building, Urban Affairs and Spatial Development, 2014, as openLCA plugin
- GreenDelta offers technical support to lecturers, tutors and students taking part in s lectures on Life Cycle Assessment at Harvard University, 2014
- Guided Case Study with CCL Label Meerane GmbH: GreenDelta consultants assist and train label-producer CCL Label employees in carrying out an LCA for one of their products
- BASF BEST: Creation of a special openLCA version for BASF, 2012-2014+ (go-live October 2013)

GreenDelta Project examples (III)

- US Department of Agriculture: Development of An EcoSpold 2 import and a regionalized impact assessment approach in openLCA, with GIS integration, 2012-2014

- US EPA 2013: Implementing a non-expert user interface and report generator for openLCA

- US EPA 2014-: GreenDelta implements a refined Life Cycle Costing approach, a semantic web import export, a new OpenIO database, and a Sustainable Material Management tool in openLCA

- Fundacíon Chile: Support in development of a data collection plugin for openLCA, for use in a study about sustainability life cycle assessment for 12 companies in the food sector, 2014-

Corporate Customers

Institutional Customers

Bundesinstitut für Bau-, Stadt- und Raumforschung
im Bundesamt für Bauwesen und Raumordnung

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Karlsruher Institut für Technologie

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

JRC
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Introducing openLCA

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)

openLCA

- native to Windows, Mac OS and Linux
- established, and growing, community of users; approx. 300 software downloads per week
- broadest selection of relevant, consistent LCI and sustainability databases available worldwide (!)

openLCA application (generic)

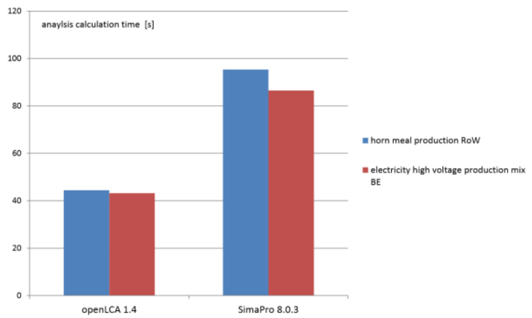
- Life Cycle Assessment, Life Cycle Costing, Social Life Cycle Assessment
- Carbon & Water footprint
- Product Environmental Footprint
- Environmental Product Declarations
- US Environmental Protection Agency’s Design for the Environment Label
- Integrated Product Policy

openLCA features overview

- All the features you expect for professional LCA modeling and analysis:

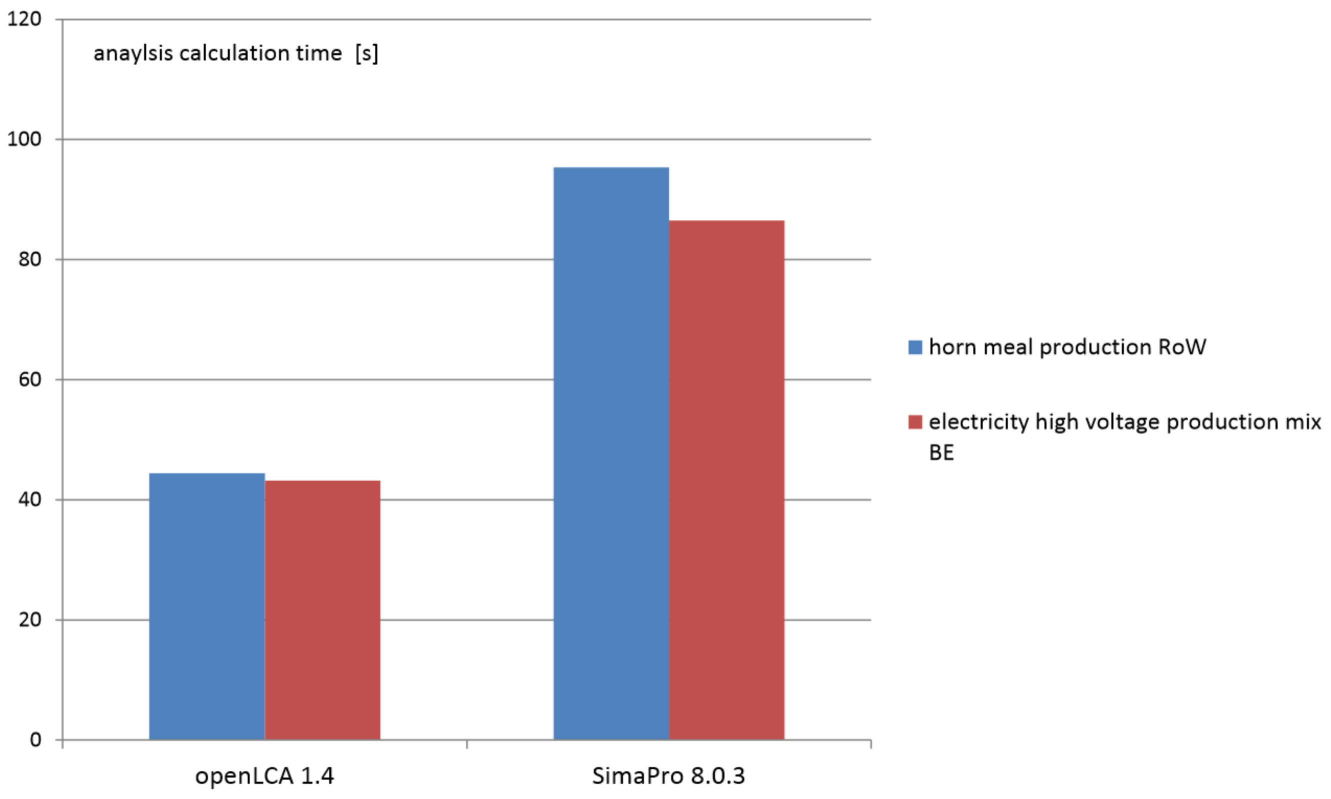
working with and creating smaller and very large product systems, “autoconnect” (as in SimaPro) or by manual connection (as in GaBi); parameters, sensitivity analysis, scripting (Javascript, Python), system expansion and allocation, uncertainty assessment, Monte Carlo Simulation, LCIA calculation with optional normalization and optional weighting, refined result analysis features, GIS integration, “best of class” import and export interfaces, group collaboration features, ...

- Fast calculation of large systems



openLCA features overview (II)

- Fast calculation of large systems: e.g. ecoinvent 3.0



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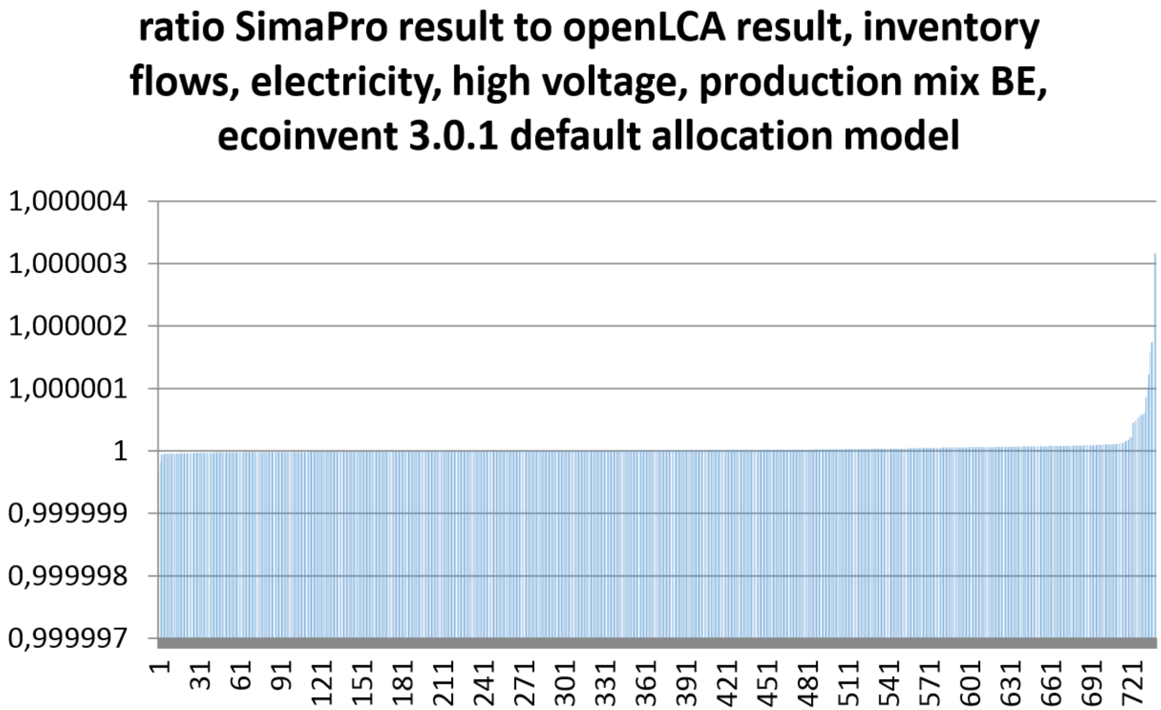
openLCA quality assurance

- External and internal testers
- Beta versions before final release → more user input



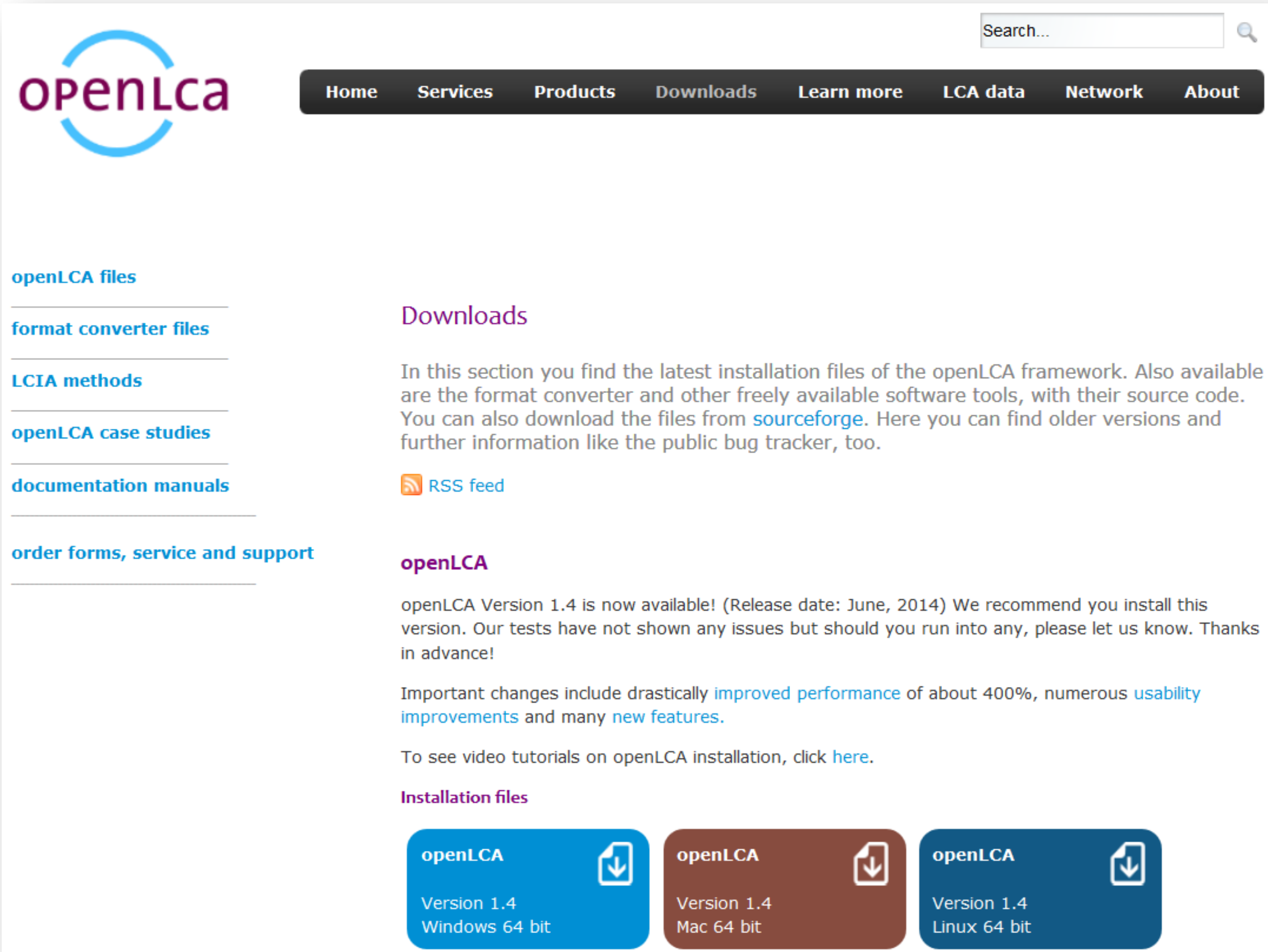
openLCA: Why open source?

- **flexibility** and **freedom**, for both user and developer
- **security, accountability and high quality** coding style is visible to everyone; "quick and dirty" solutions cannot be hidden
- **cost benefit**, despite maintenance, configuration and support costs for developer behind the scenes
- open source nature of the software makes it very **suitable for use with sensitive data** (point brought forward by Lockheed Martin, users of openLCA)
- **No further obligations for users**, especially no obligation to share / distribute / … created LCA processes and systems

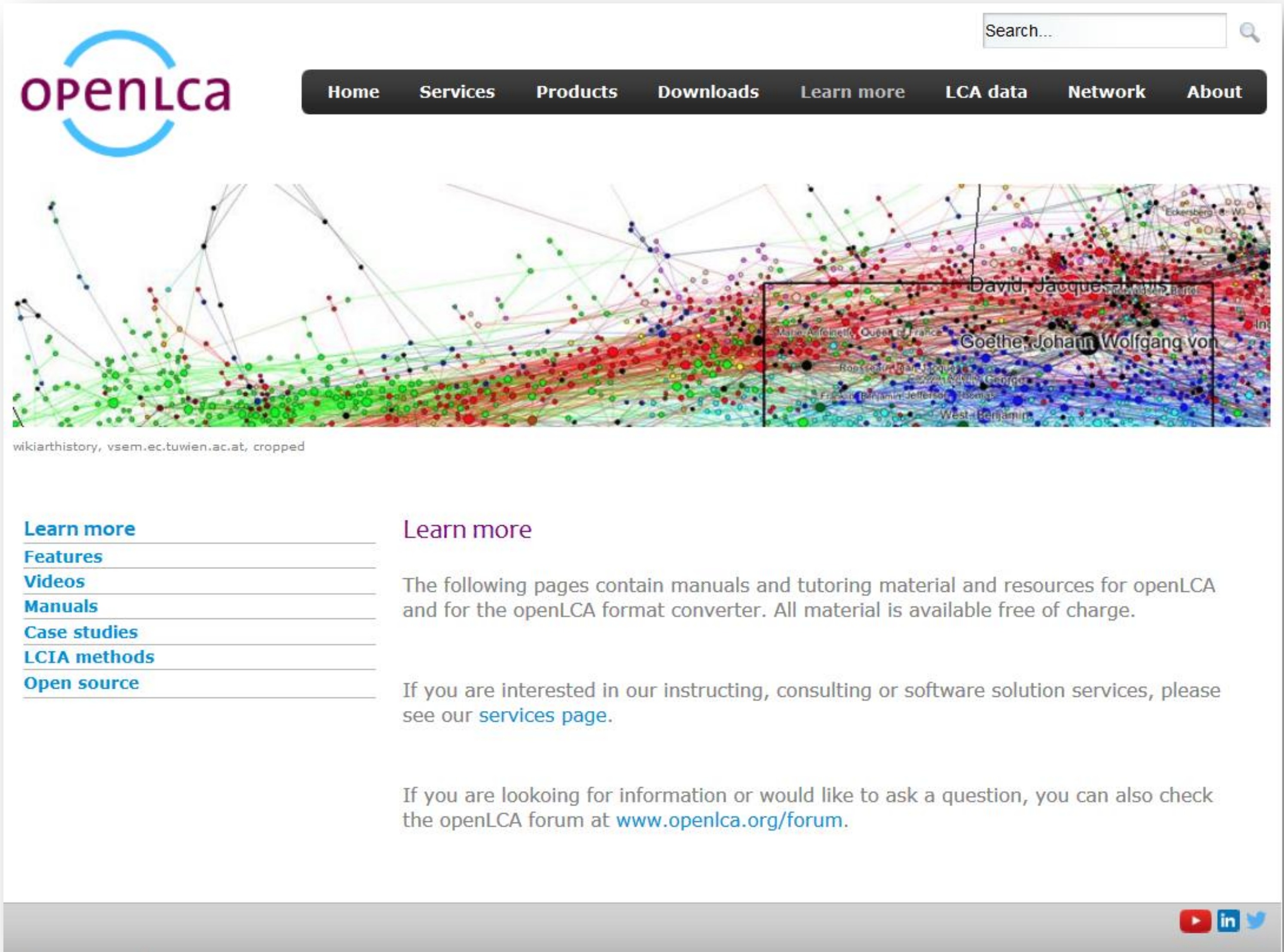
openLCA.org

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

openLCA.org/downloads



openLCA.org/learnmore



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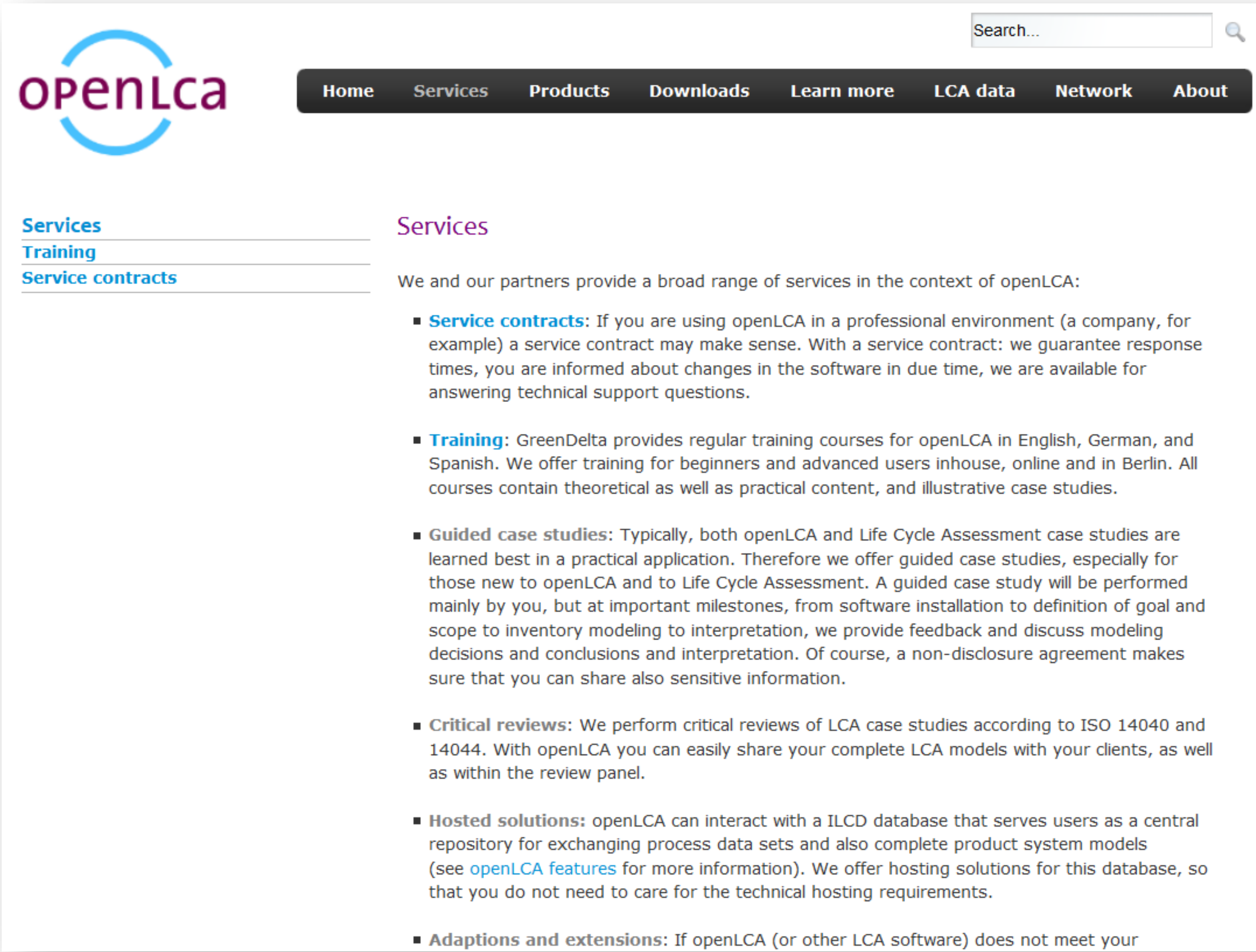
openLCA.org/services



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- Services
- Training
- Service contracts

Services

We and our partners provide a broad range of services in the context of openLCA:

- **Service contracts**: If you are using openLCA in a professional environment (a company, for example) a service contract may make sense. With a service contract: we guarantee response times, you are informed about changes in the software in due time, we are available for answering technical support questions.
- **Training**: GreenDelta provides regular training courses for openLCA in English, German, and Spanish. We offer training for beginners and advanced users inhouse, online and in Berlin. All courses contain theoretical as well as practical content, and illustrative case studies.
- **Guided case studies**: Typically, both openLCA and Life Cycle Assessment case studies are learned best in a practical application. Therefore we offer guided case studies, especially for those new to openLCA and to Life Cycle Assessment. A guided case study will be performed mainly by you, but at important milestones, from software installation to definition of goal and scope to inventory modeling to interpretation, we provide feedback and discuss modeling decisions and conclusions and interpretation. Of course, a non-disclosure agreement makes sure that you can share also sensitive information.
- **Critical reviews**: We perform critical reviews of LCA case studies according to ISO 14040 and 14044. With openLCA you can easily share your complete LCA models with your clients, as well as within the review panel.
- **Hosted solutions:** openLCA can interact with a ILCD database that serves users as a central repository for exchanging process data sets and also complete product system models (see openLCA features for more information). We offer hosting solutions for this database, so that you do not need to care for the technical hosting requirements.
- **Adaptions and extensions**: If openLCA (or other LCA software) does not meet your

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openLCA.org/forum

openLCA user forum

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Board index

FAQ Register Login

It is currently 02 Sep 2014 14:05

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FORUM	TOPICS	POSTS	LAST POST
openLCA 1.4	23	73	by aciroth 11 Aug 2014 13:46
Installation	25	103	by aciroth 02 Sep 2014 13:18
Modelling	78	236	by aciroth 27 Aug 2014 16:30
Data and Data Exchange	66	233	by aciroth 23 Aug 2014 09:17
Developer	13	45	by aciroth 26 Jun 2014 17:09
Other	17	52	by MartinaZ 11 Jun 2014 11:19
Version 1.2 test Forum for the July 2010 (+..) test round of openLCA	6	17	by aciroth 01 Jun 2013 12:48

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WHO IS ONLINE

In total there are **2** users online :: 0 registered, 0 hidden and 2 guests (based on users active over the past 5 minutes)
Most users ever online was **54** on 30 Jun 2013 00:22

Registered users: No registered users

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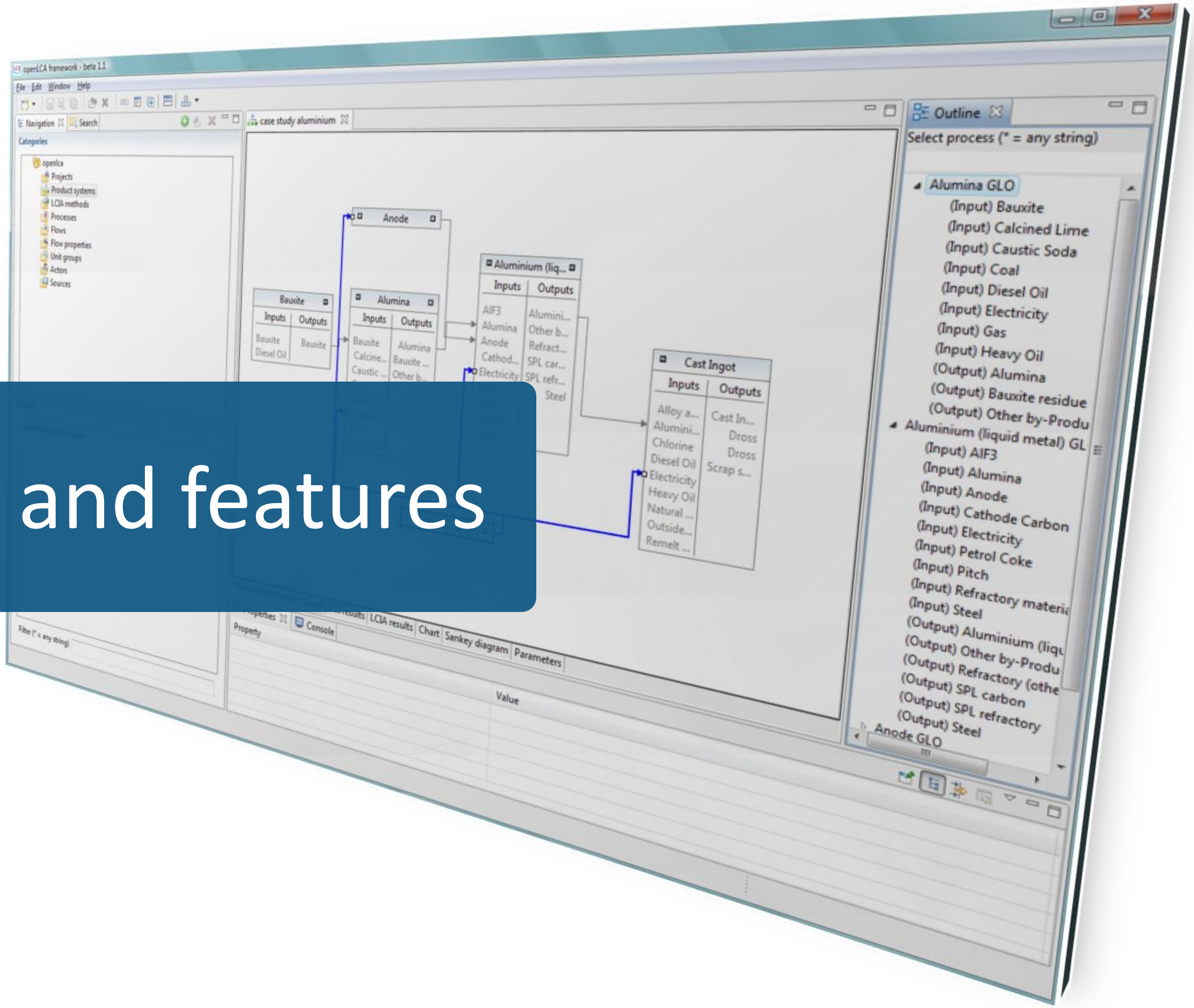
Functions and features

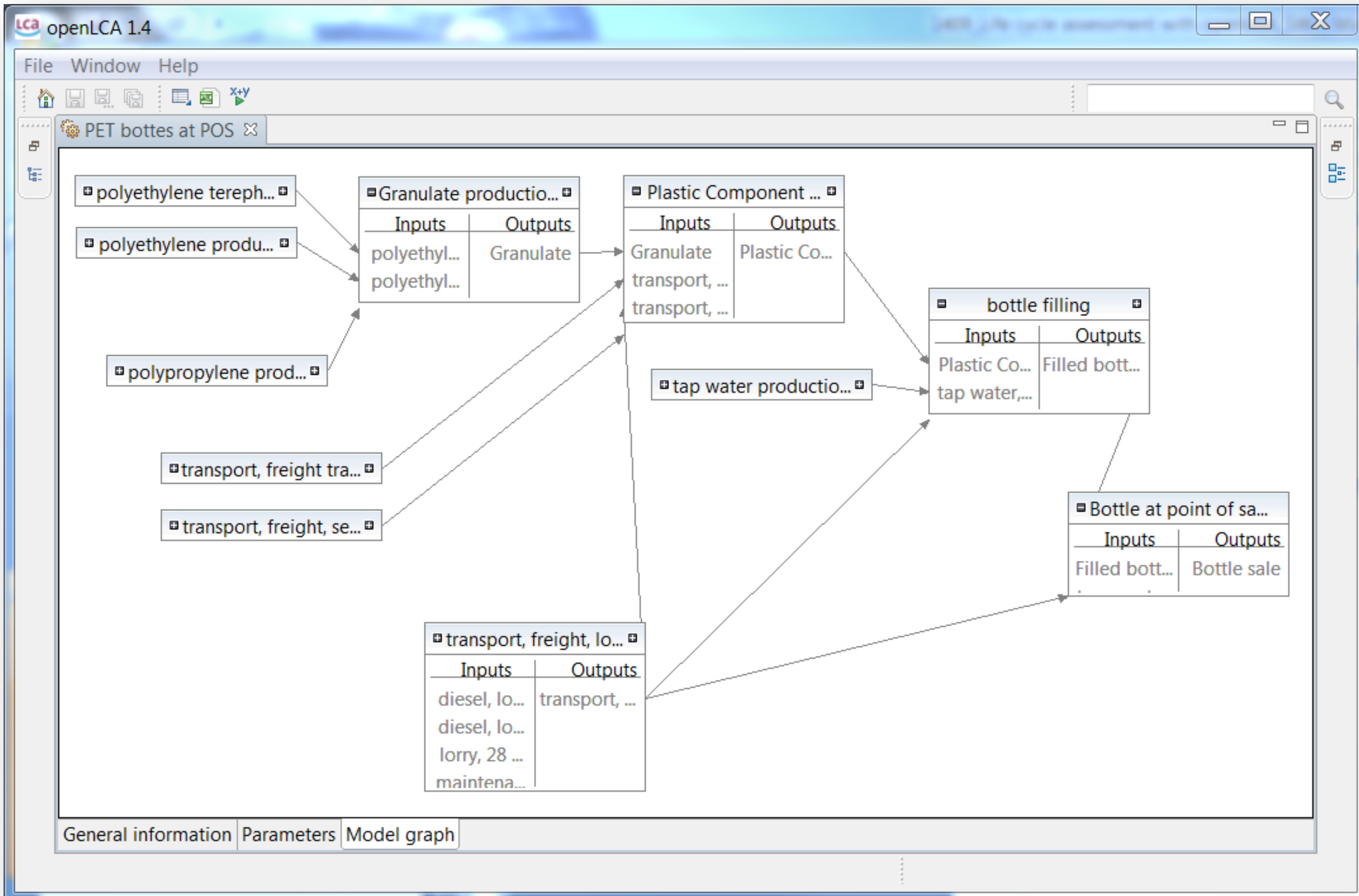


Graphical modeling of product systems

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

Graphic modeling of process networks based on Eclipse GEF



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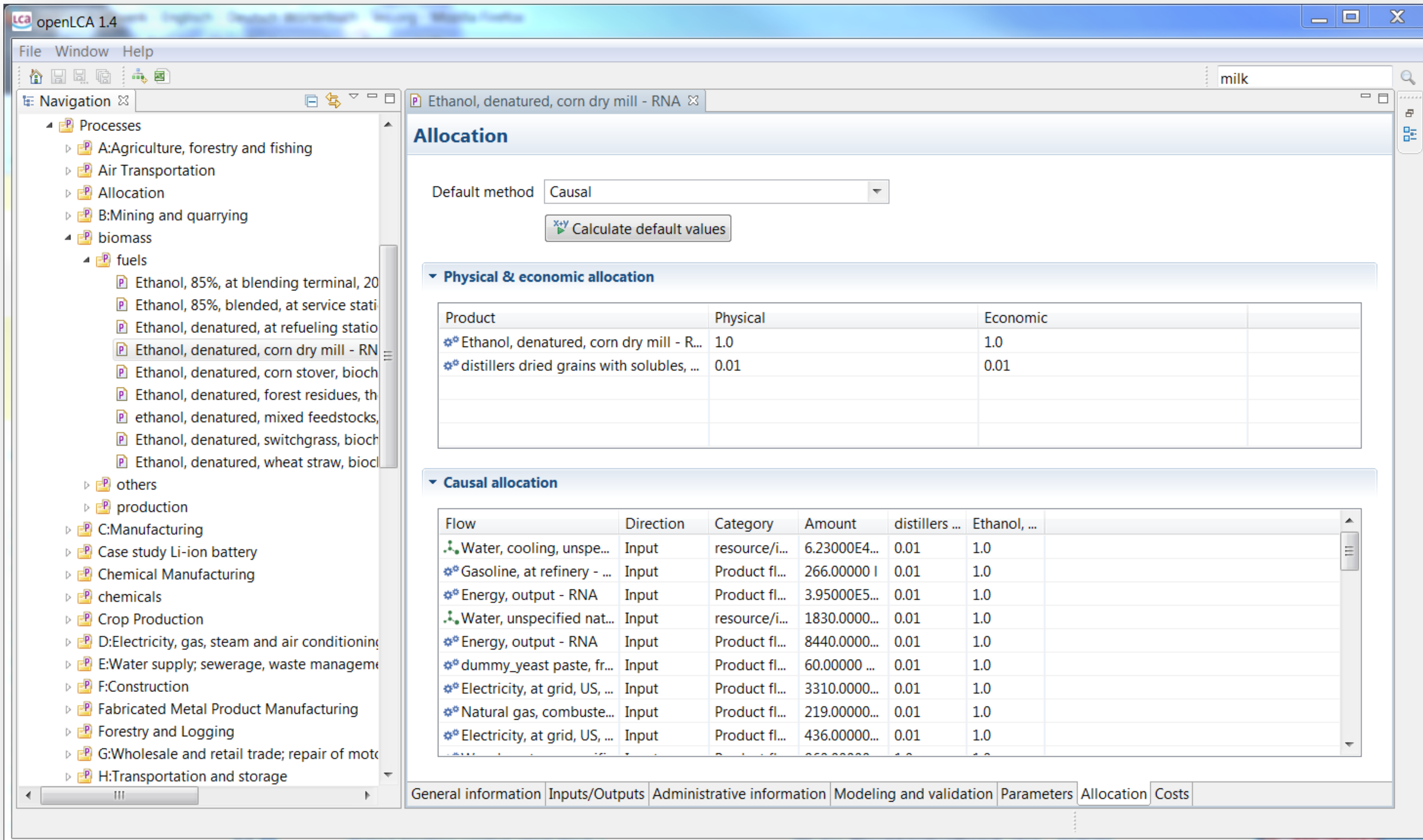
Allocation and system expansion for modeling multi-output processes



Modeling with parameters

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

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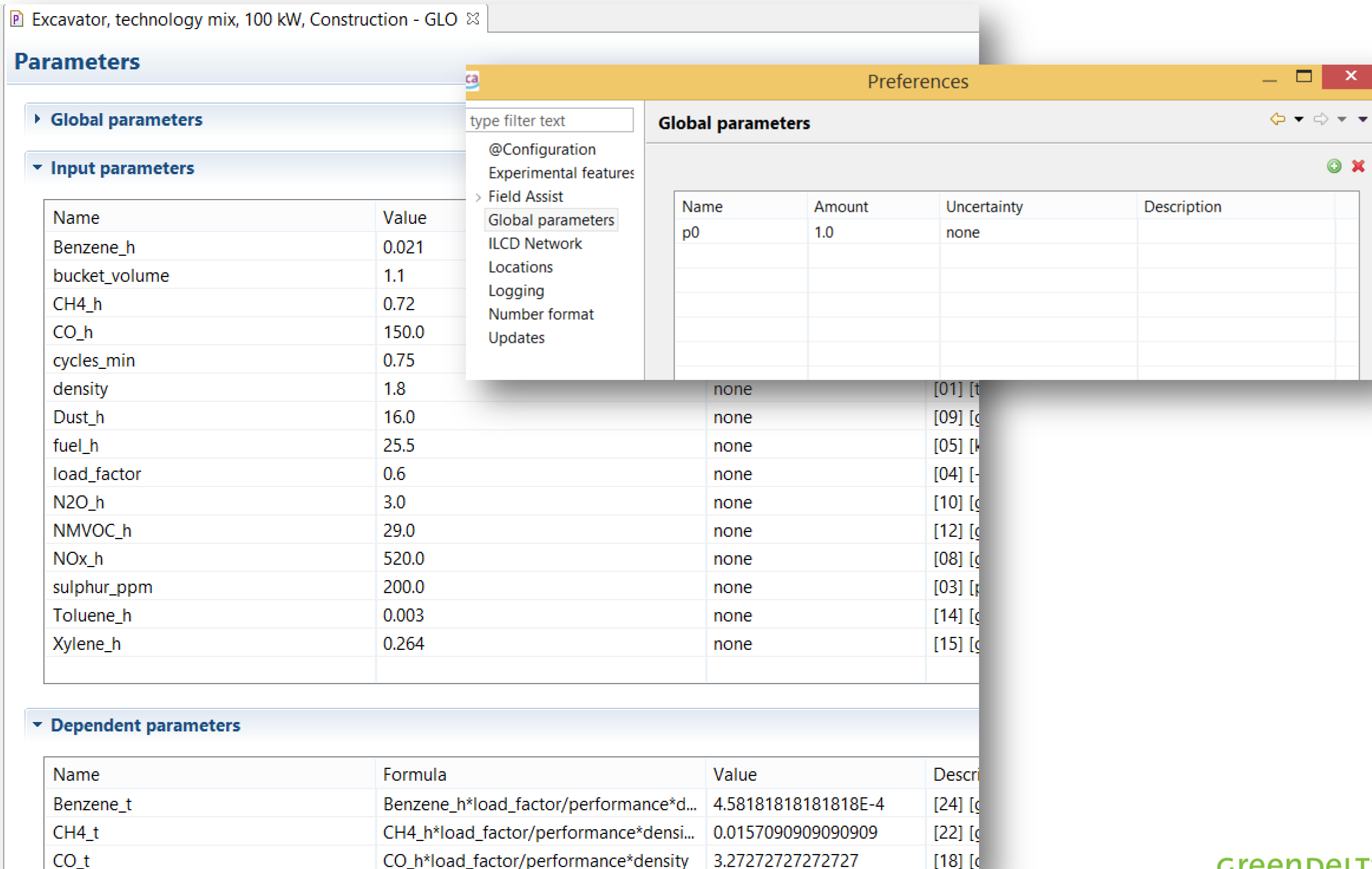
Local and global parameters



Inventory calculation

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

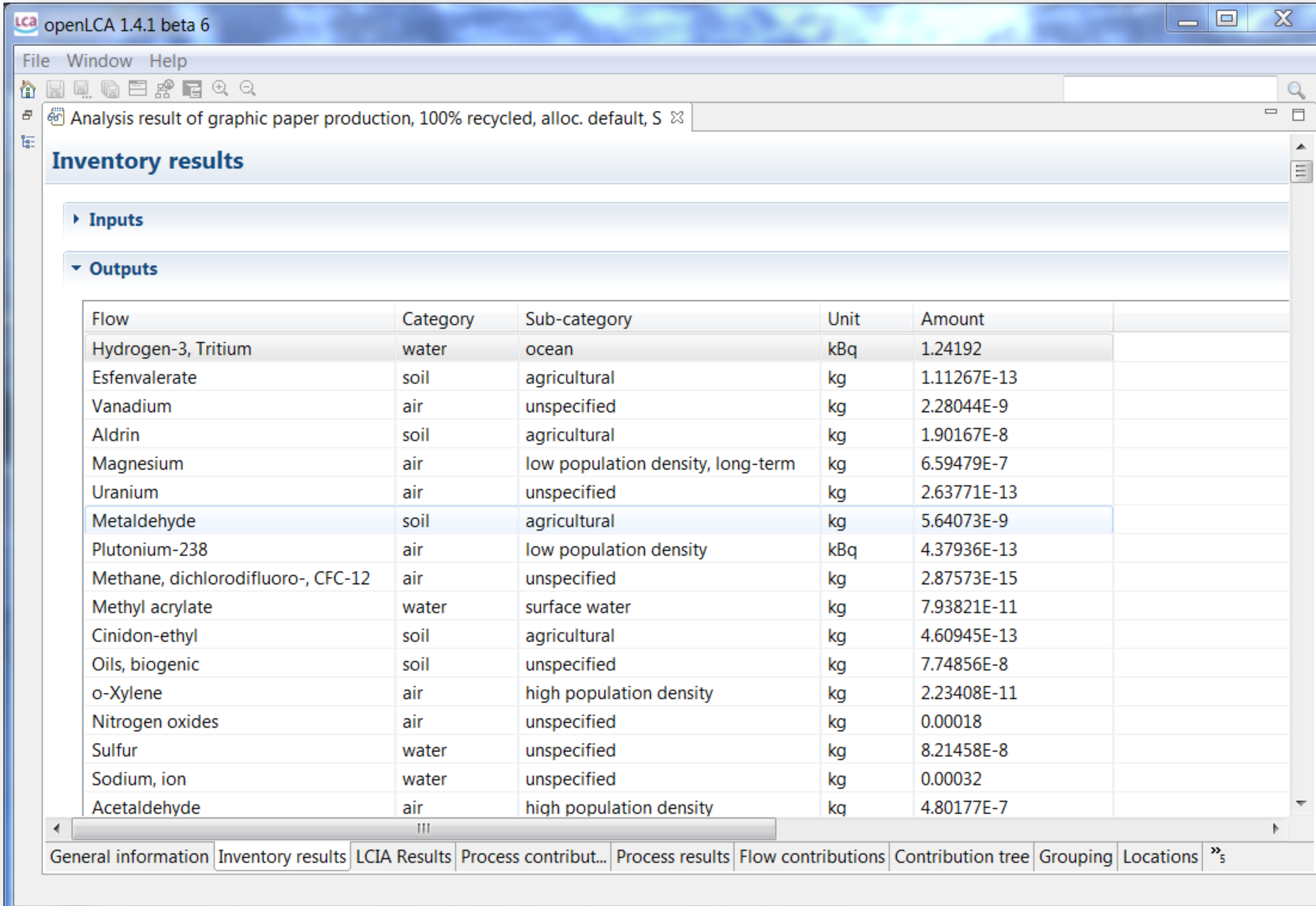
Matrix calucation method

```
> 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]                 0.000878              0          1.17        0.29         0.35          0.16
SO2 [kg]                 0.001700              0          5.30        1.70        13.40          0.29
> f
                              [,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.     0.385434
Electrolysis    0.874000
Ingot casting   1.000000
> g
                            [,1]
Crude oil [kg]        -17.018990
Bauxite [kg]        -4517.378250
CO2 / CO2 equ. [kg] 11138.388062
NOx [kg]                2.556104
SO2 [kg]               21.593111
>
```

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

$$g = B \cdot s$$

Example: inventory results



Flow	Category	Sub-category	Unit	Amount
Hydrogen-3, Tritium	water	ocean	kBq	1.24192
Esfenvalerate	soil	agricultural	kg	1.11267E-13
Vanadium	air	unspecified	kg	2.28044E-9
Aldrin	soil	agricultural	kg	1.90167E-8
Magnesium	air	low population density, long-term	kg	6.59479E-7
Uranium	air	unspecified	kg	2.63771E-13
Metaldehyde	soil	agricultural	kg	5.64073E-9
Plutonium-238	air	low population density	kBq	4.37936E-13
Methane, dichlorodifluoro-, CFC-12	air	unspecified	kg	2.87573E-15
Methyl acrylate	water	surface water	kg	7.93821E-11
Cinidon-ethyl	soil	agricultural	kg	4.60945E-13
Oils, biogenic	soil	unspecified	kg	7.74856E-8
o-Xylene	air	high population density	kg	2.23408E-11
Nitrogen oxides	air	unspecified	kg	0.00018
Sulfur	water	unspecified	kg	8.21458E-8
Sodium, ion	water	unspecified	kg	0.00032
Acetaldehyde	air	high population density	kg	4.80177E-7

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

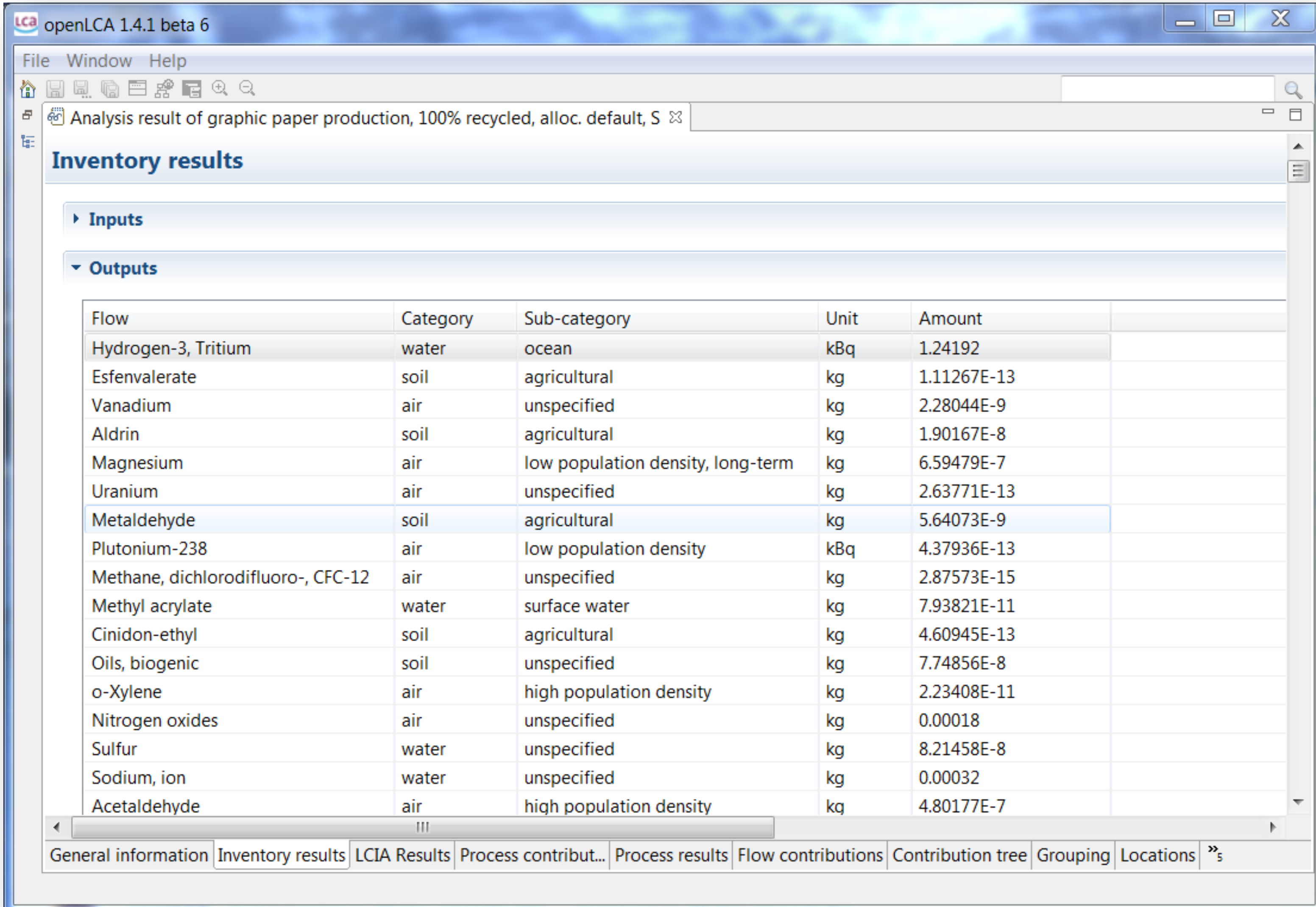
- It is possible to modify existing impact assessment methods in openLCA (impact categories and flows can be added / deleted; equivalence factors can be altered)

- It is also possible to create new impact assessment methods

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)
  - ...

Contribution analyses



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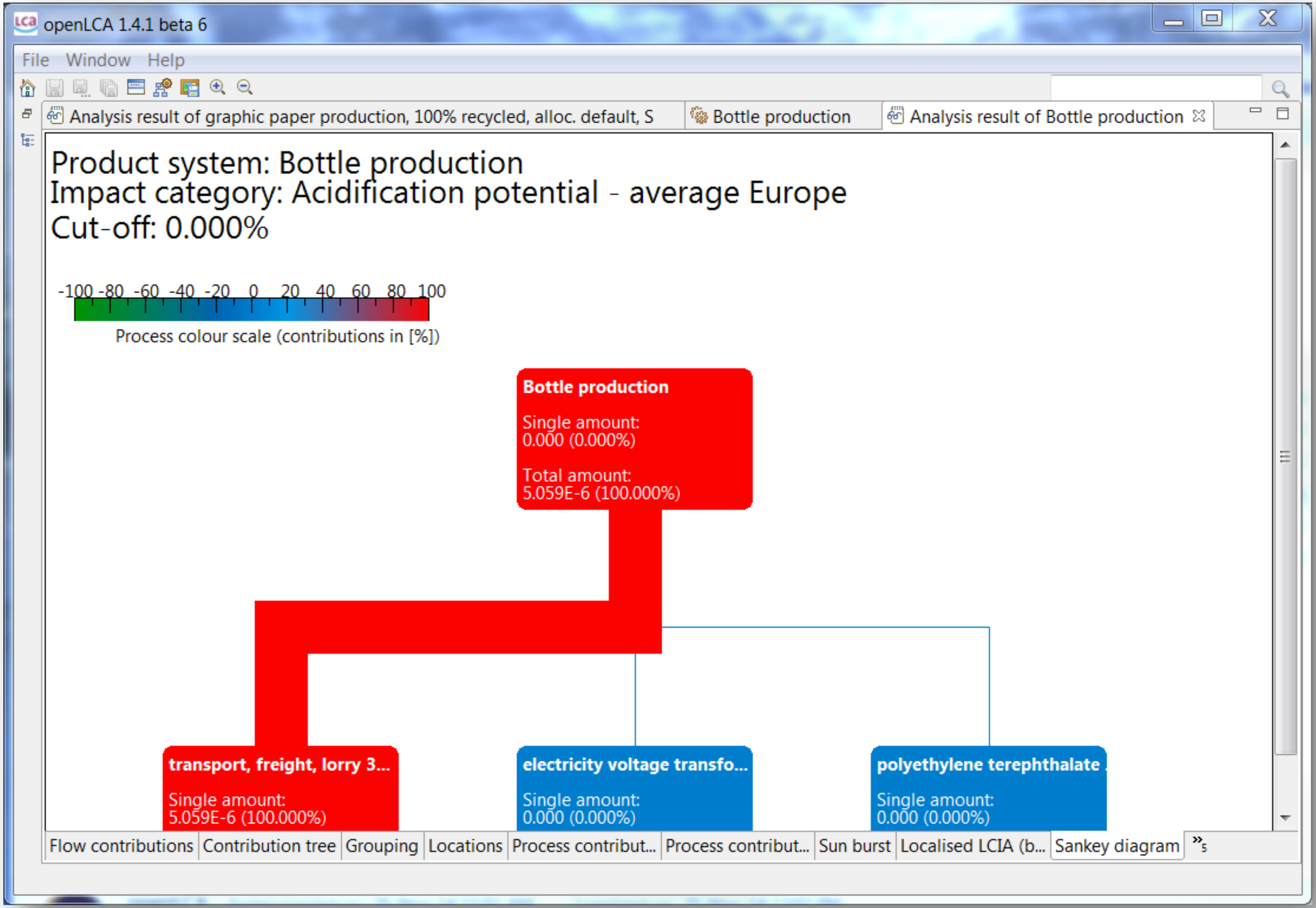
Sankey-Diagram



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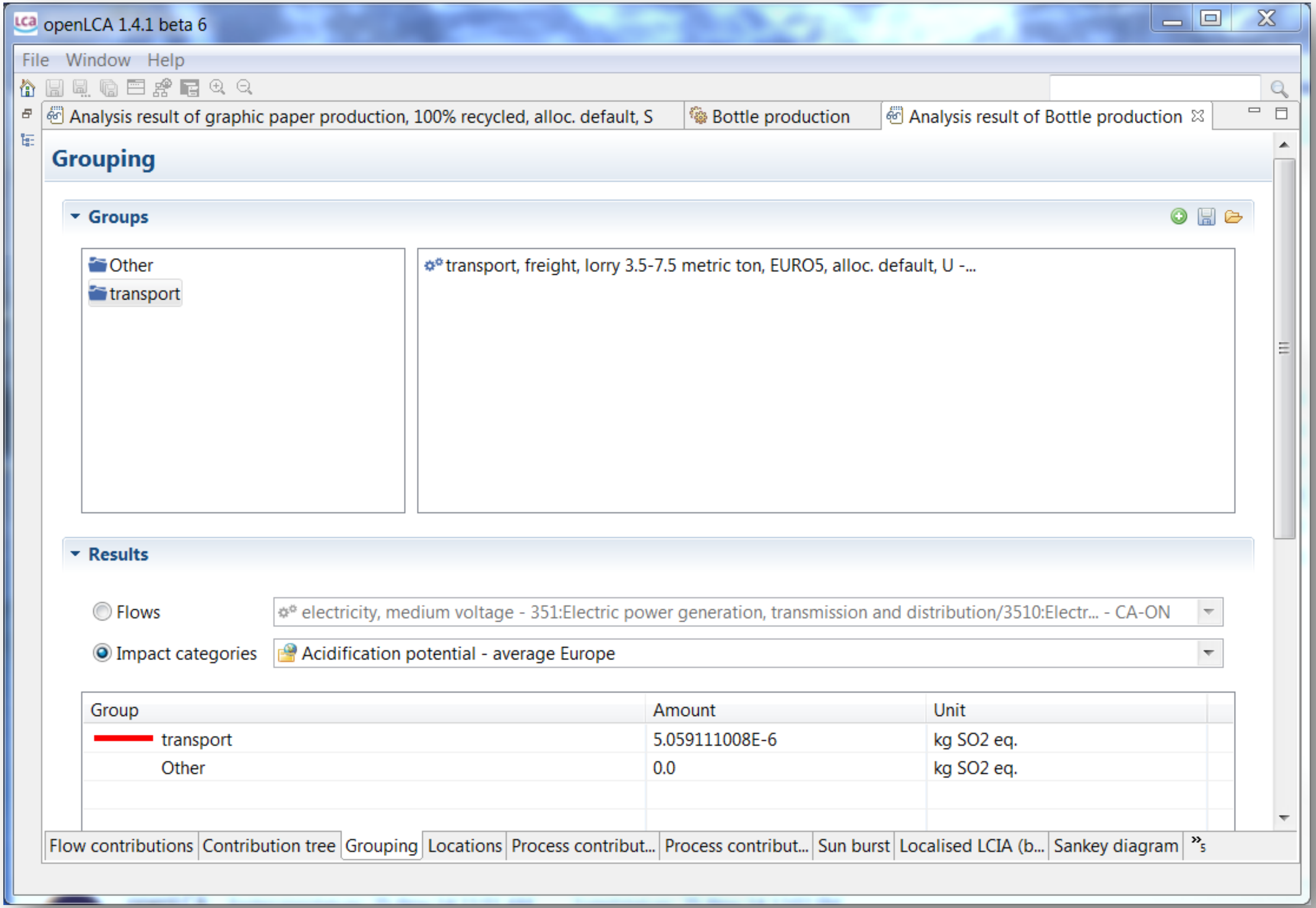
Grouping



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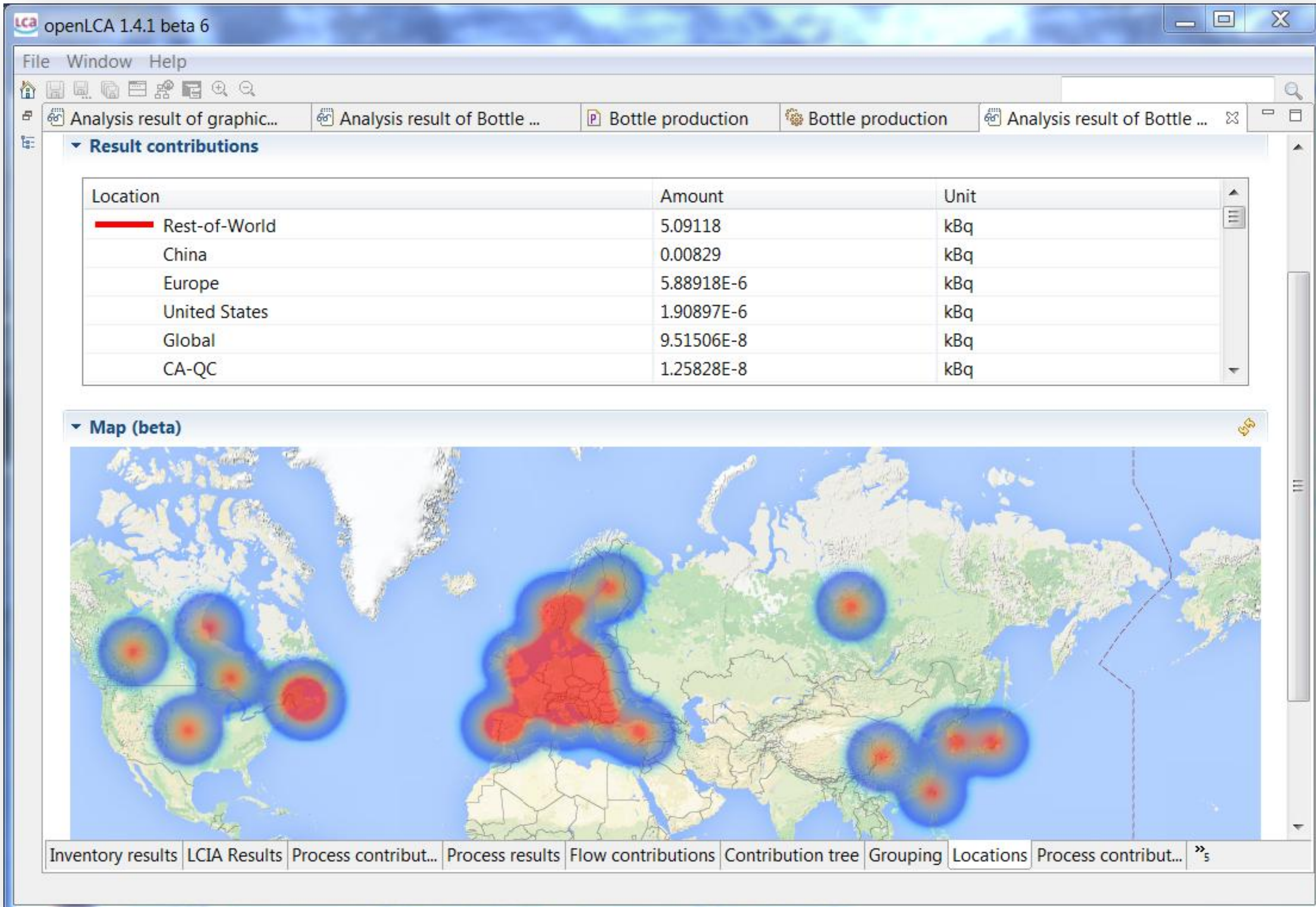
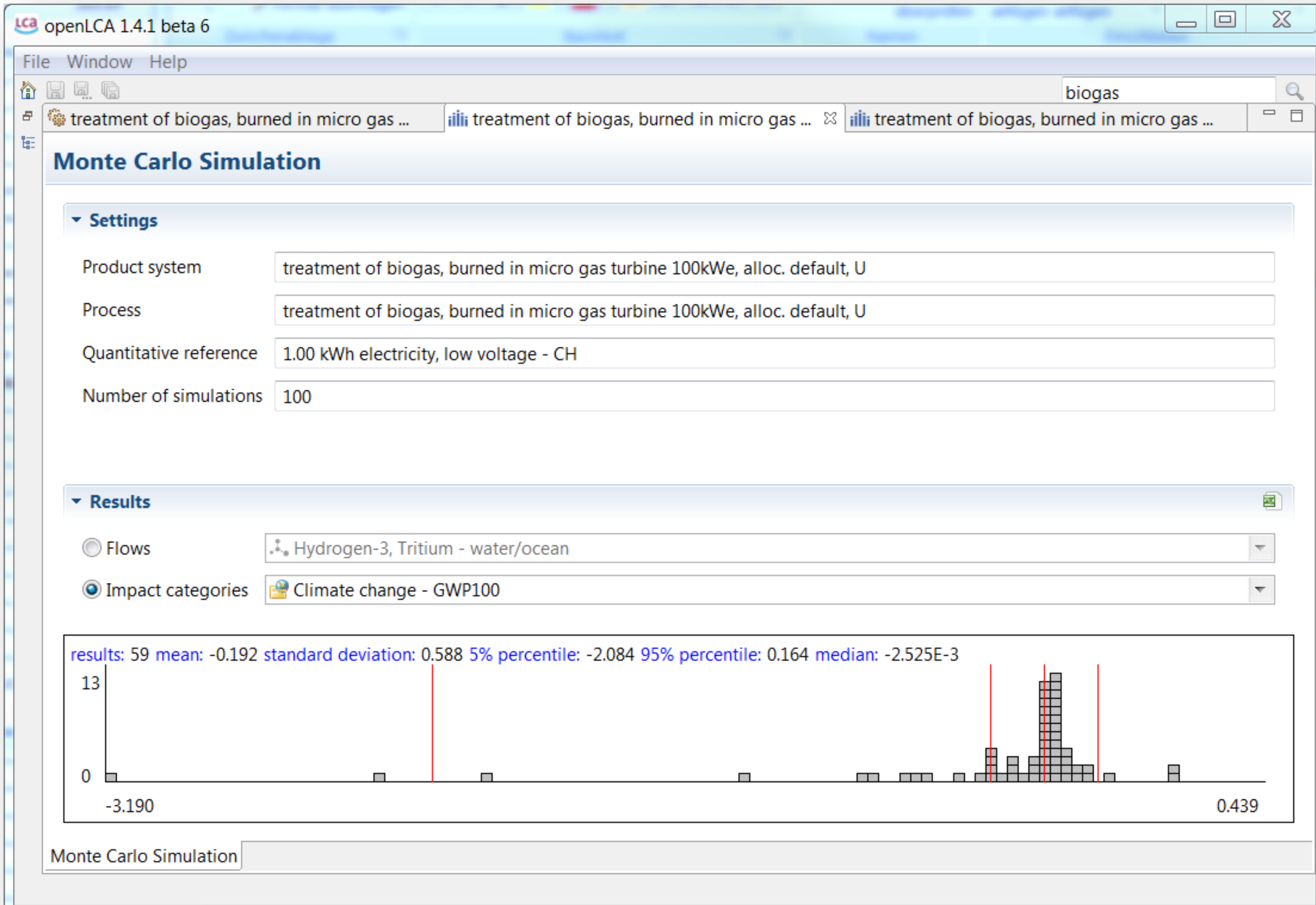
Localisation



Uncertainty analyses

.. with Monte-Carlo-Simulation or pedigree approach



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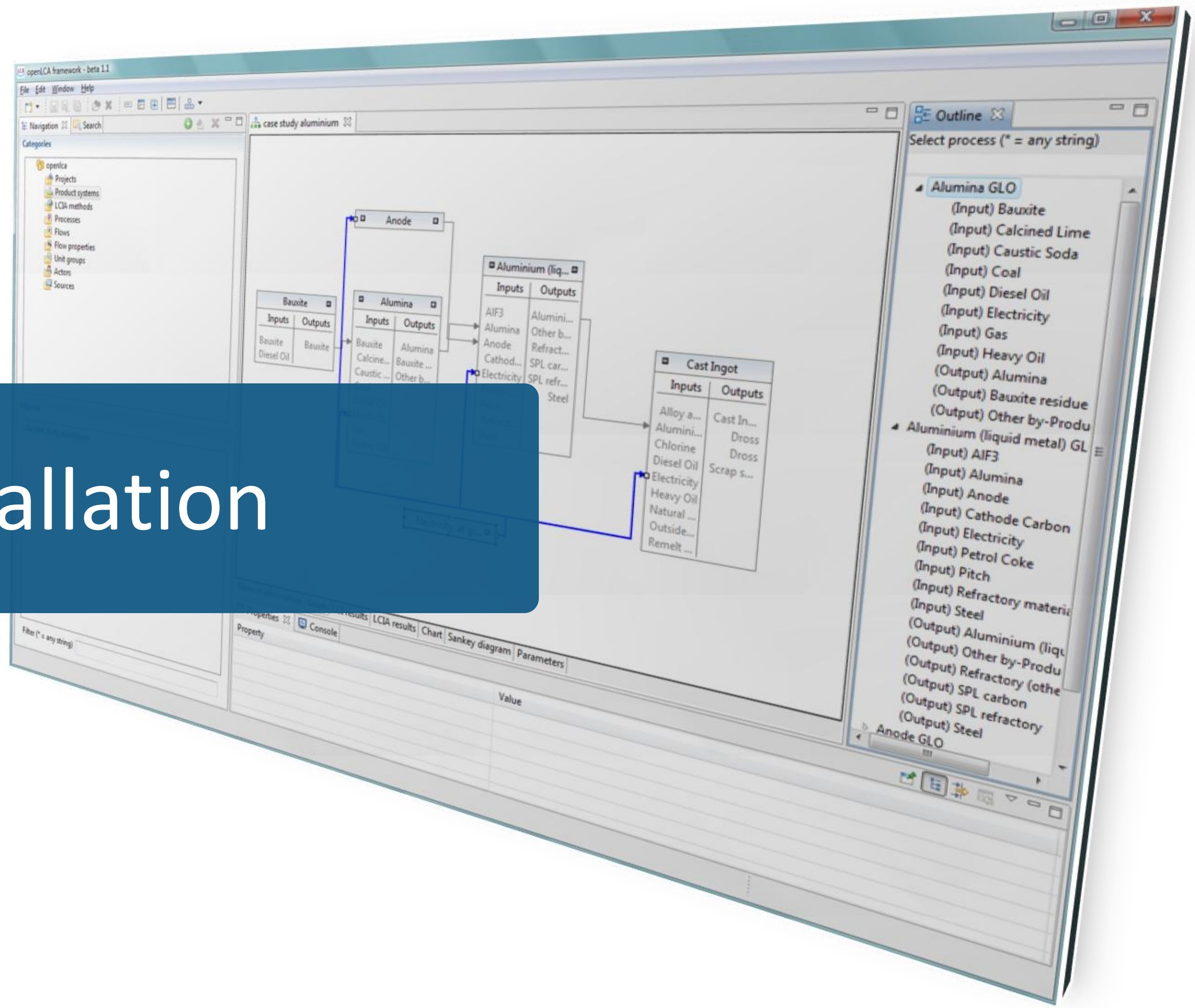
Further characteristics

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

Installation



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)

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Download and installation of openLCA

Download openLCA at http://openlca.org/downloads/

openLCA

openLCA Version 1.4 is now available! (Release date: June, 2014) We recommend you install this version. Our tests have not shown any issues but should you run into any, please let us know. Thanks in advance!

Important changes include drastically improved performance of about 400%, numerous usability improvements and many new features.

To see video tutorials on openLCA installation, click here.

Installation files

openLCA
Version 1.4
Windows 64 bit

openLCA
Version 1.4
Mac 64 bit

openLCA
Version 1.4
Linux 64 bit

openLCA
Version 1.4
Windows 32 bit

zip files for openLCA - just unzip and run openLCA, no installation needed, several versions of openLCA can be "installed" in parallel:

openLCA 1.4 Windows 64 bit
openLCA 1.4 Windows 32 bit

openLCA installer

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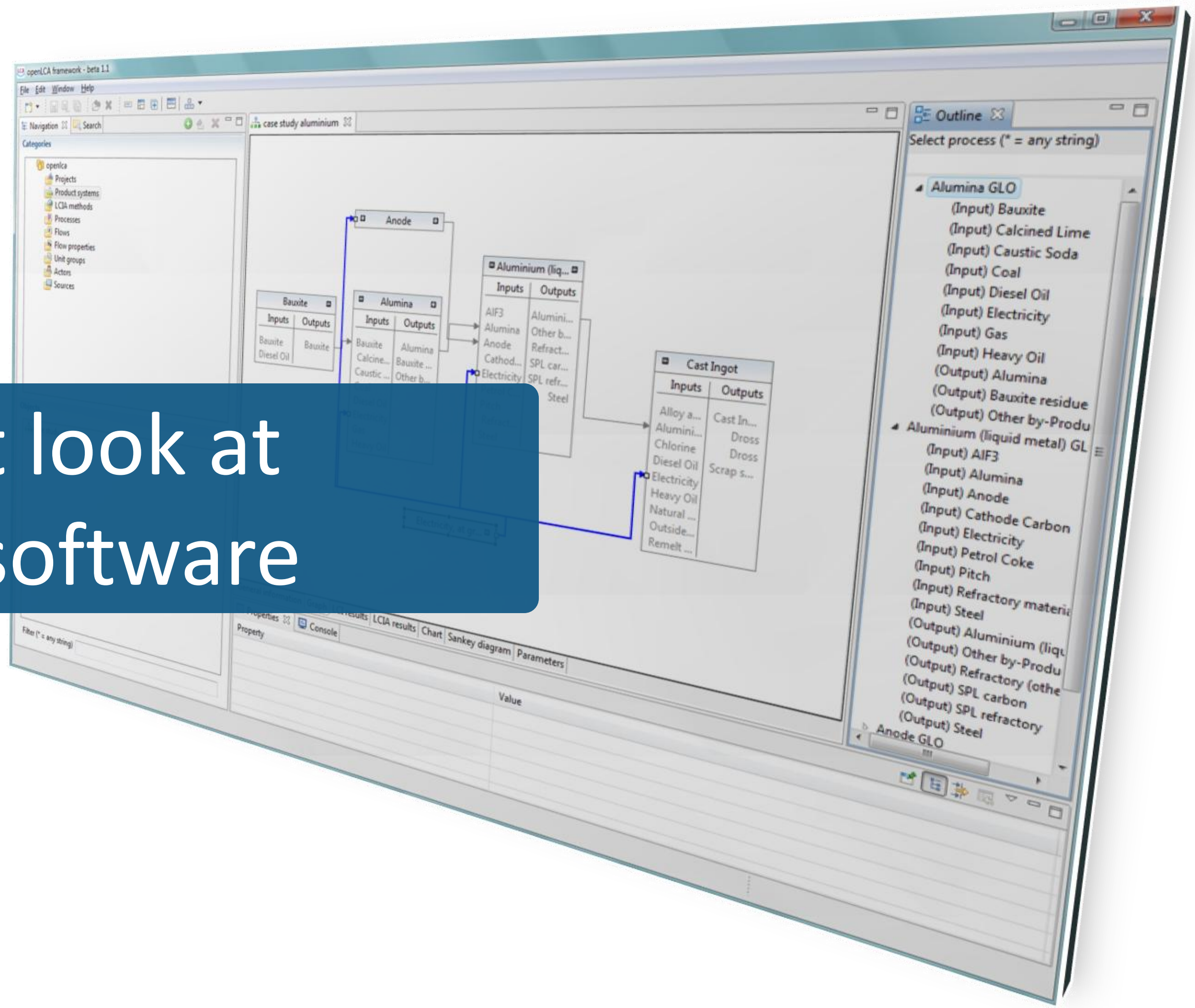
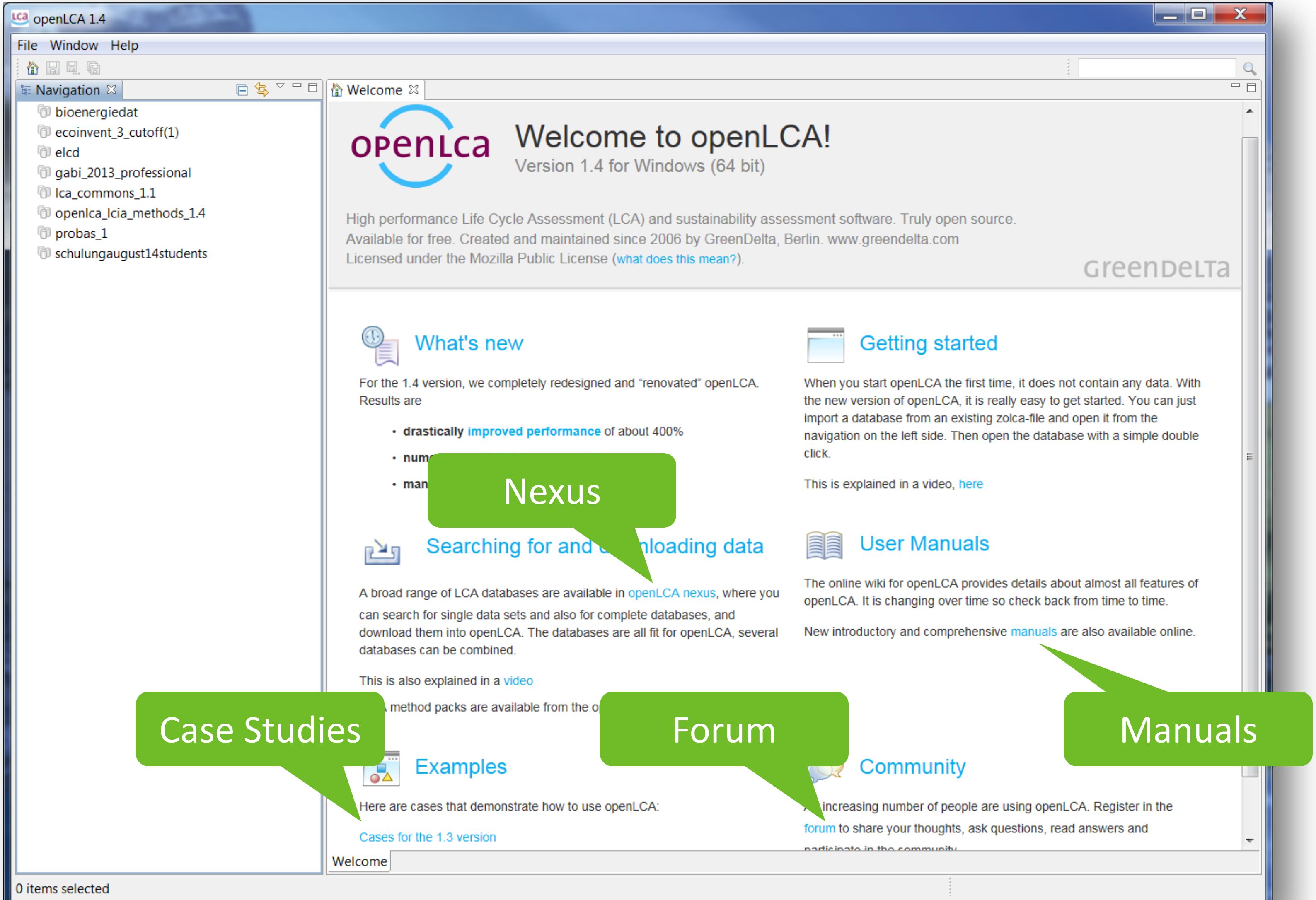
First look at the software



Welcome to openLCA!



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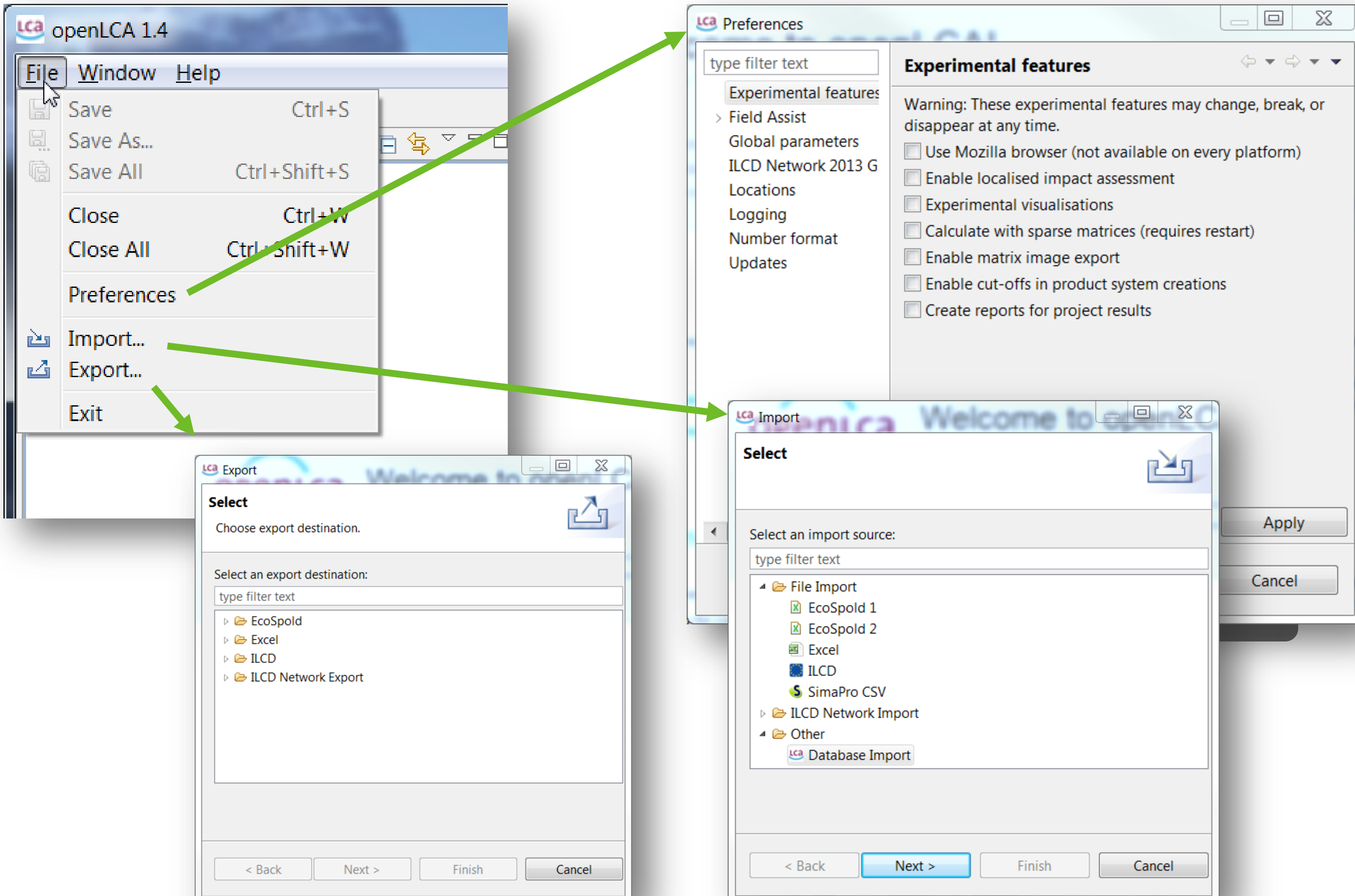
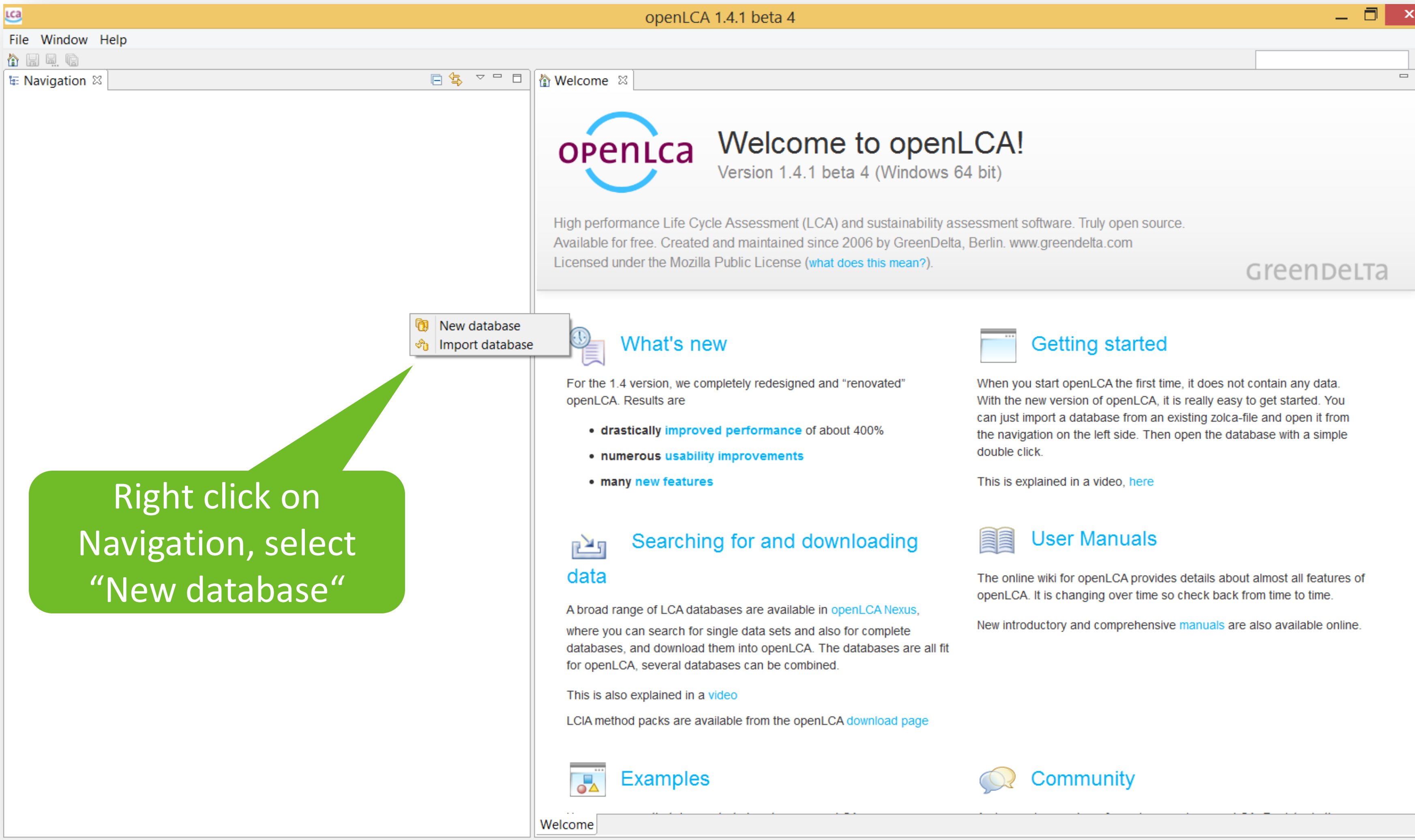
Main menu functions

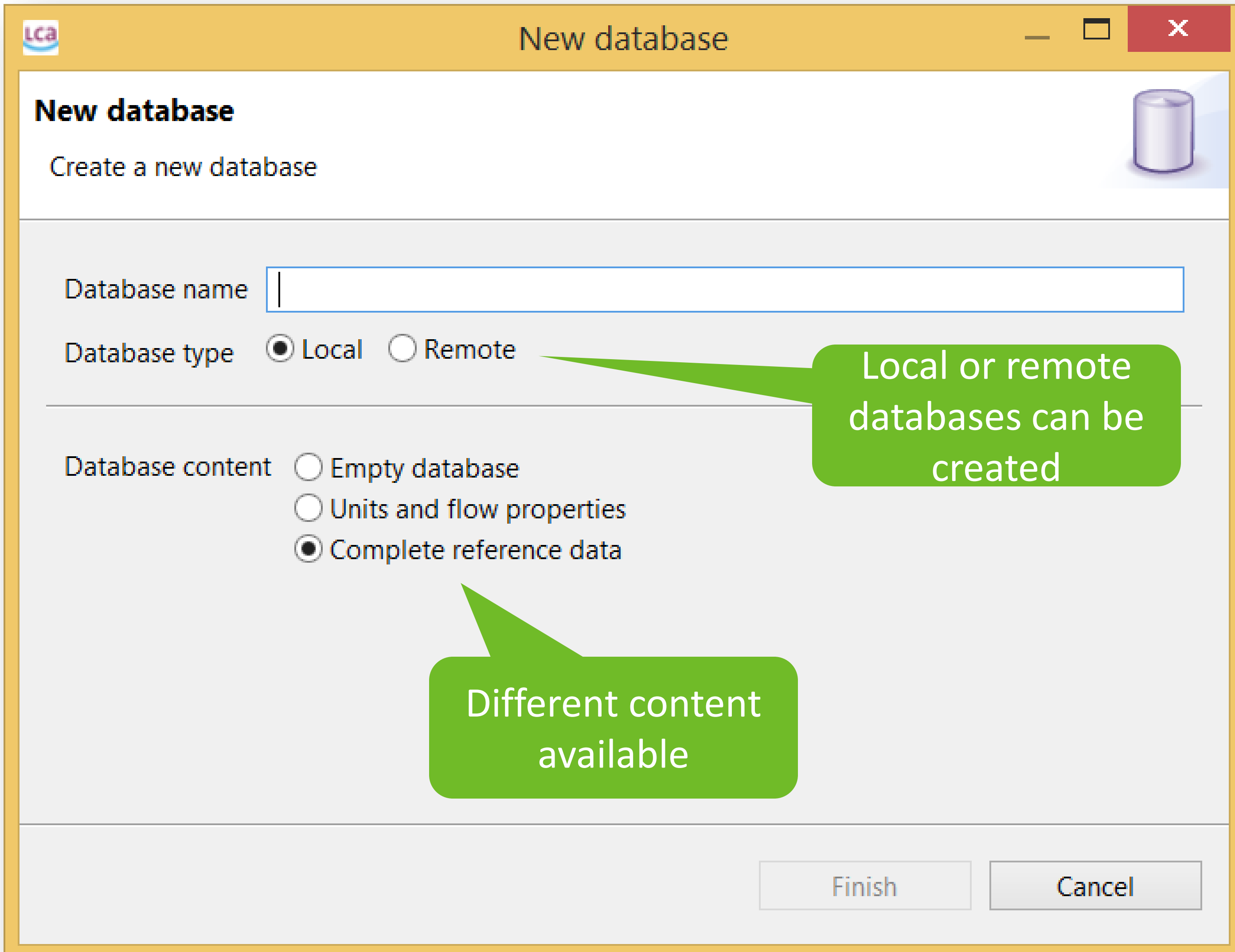


Create a new database



Right click on Navigation, select "New database"

Create a new database (II)



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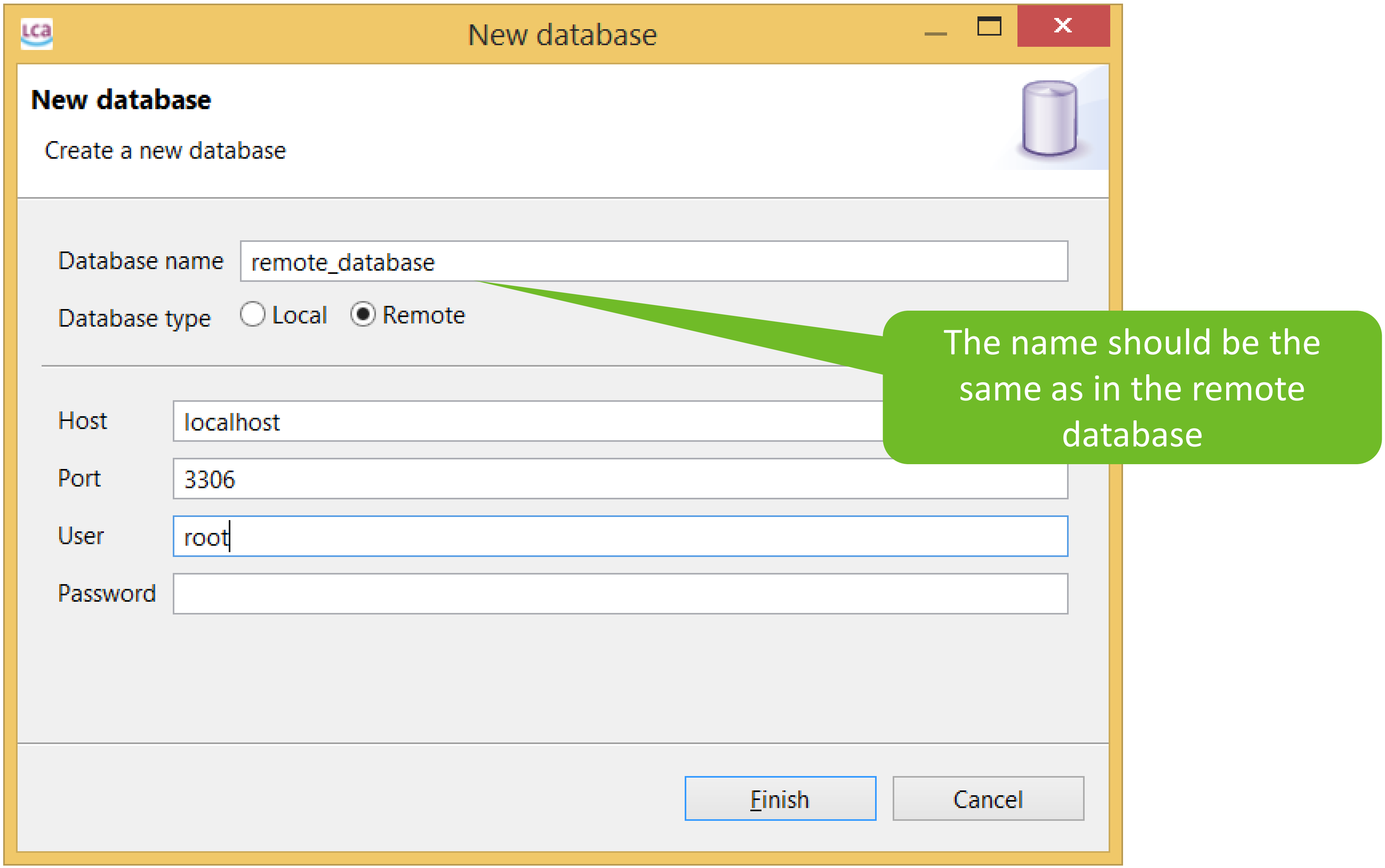
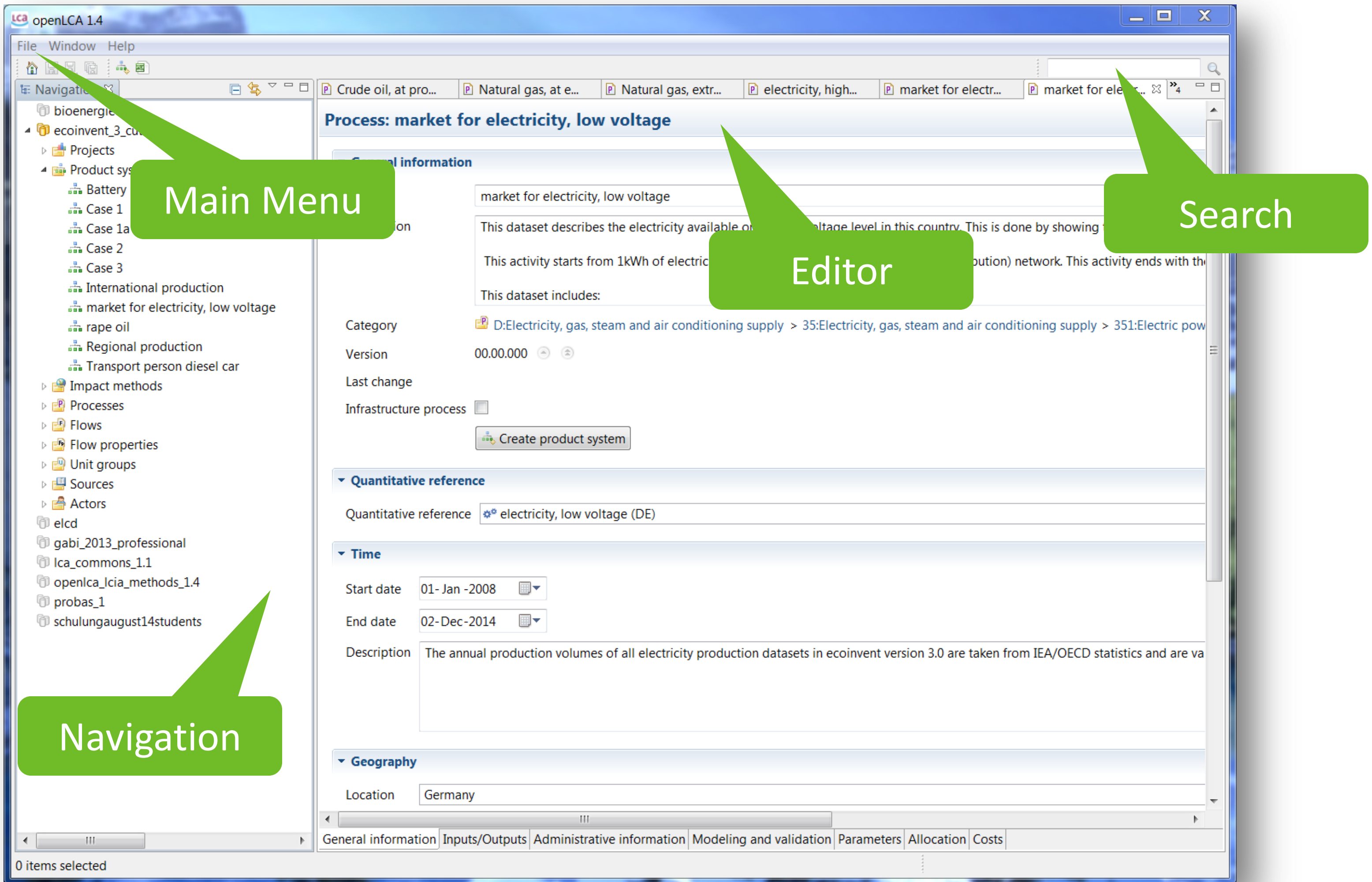
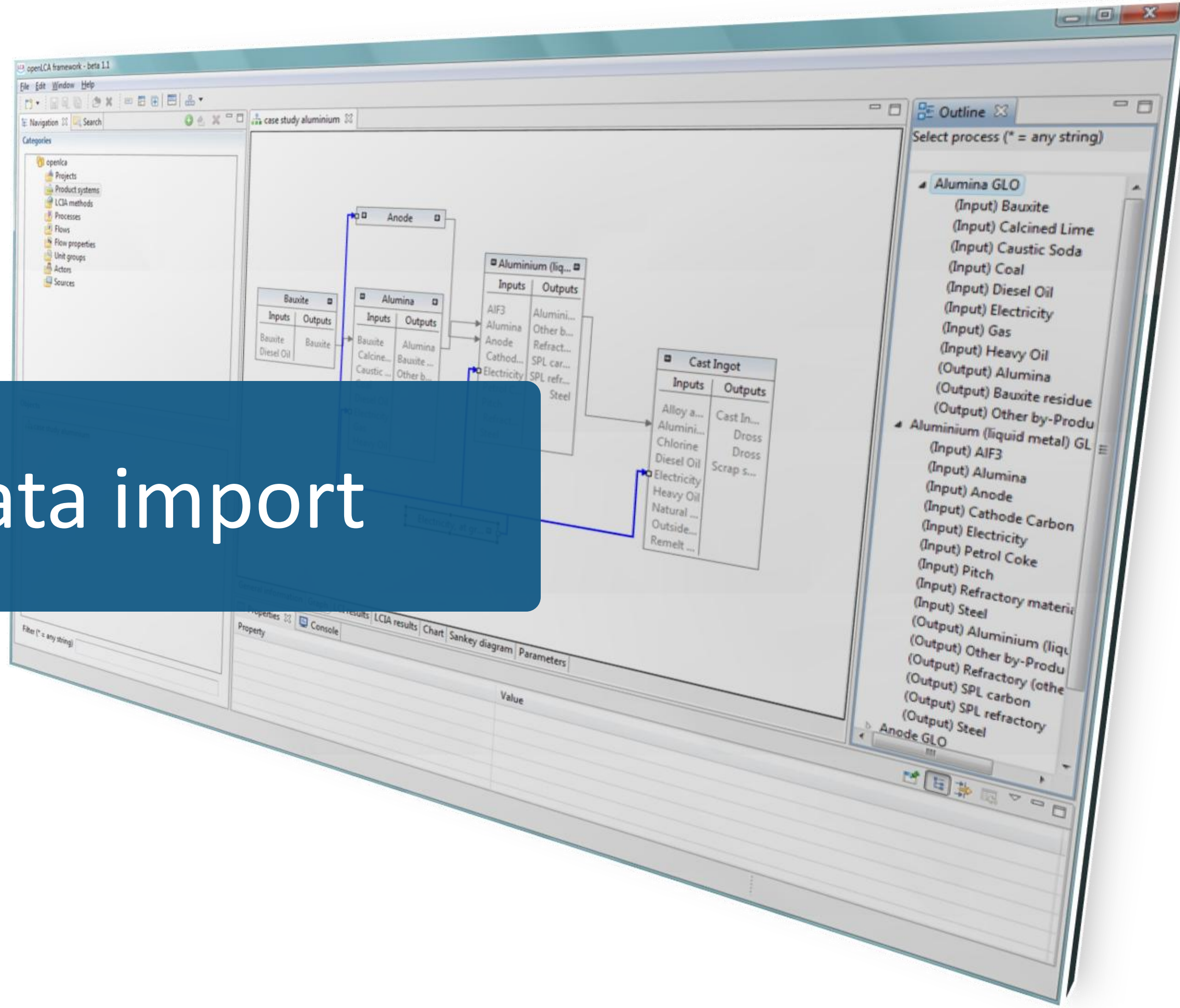
Create a new database (III)



openLCA overview



LCA data import



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 und Export formats:
  - EcoSpold1
  - ILCD
  - EcoSpold2
  - Excel
  - SimaPro CSV
  - zolca
- 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

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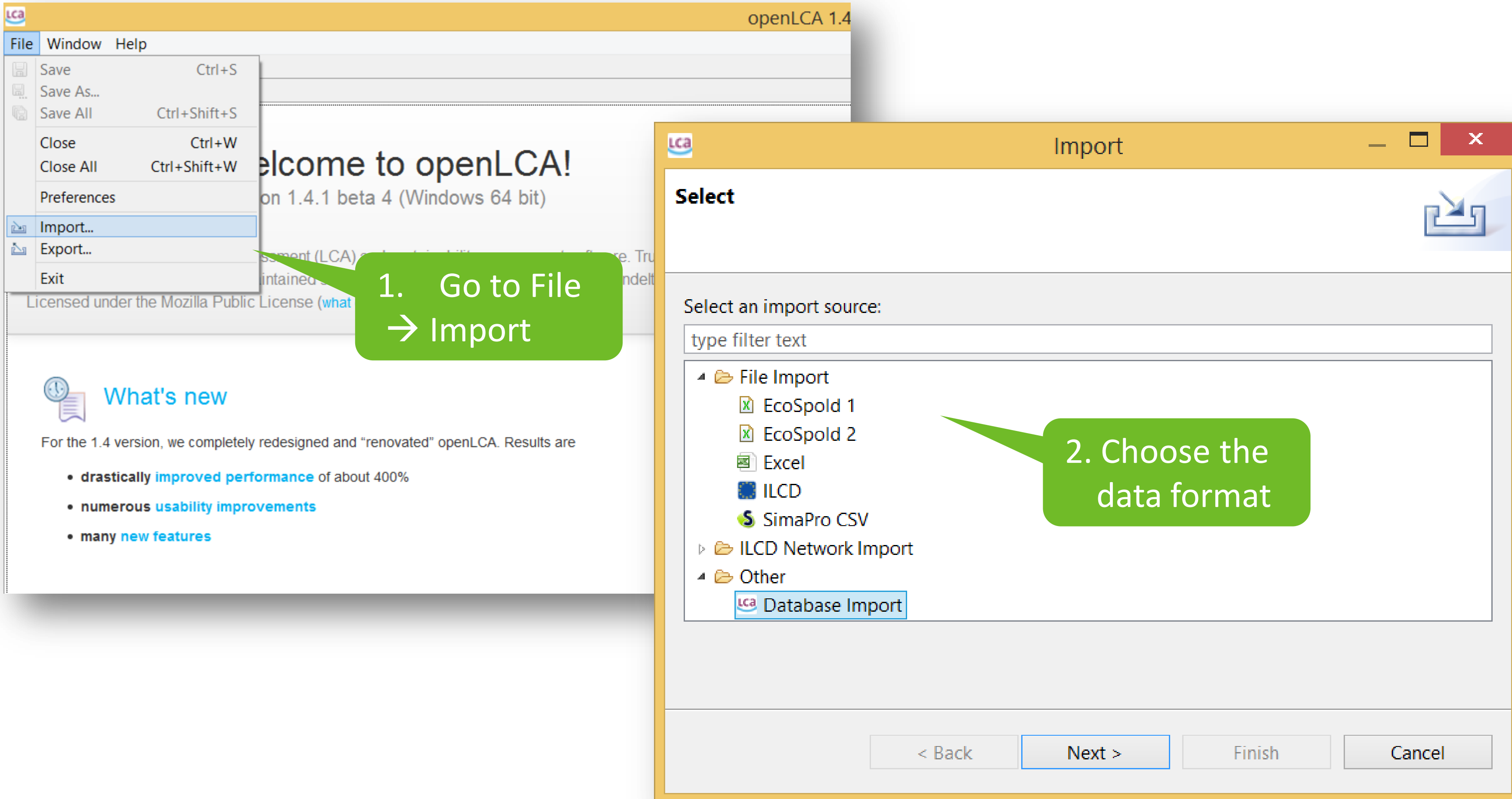
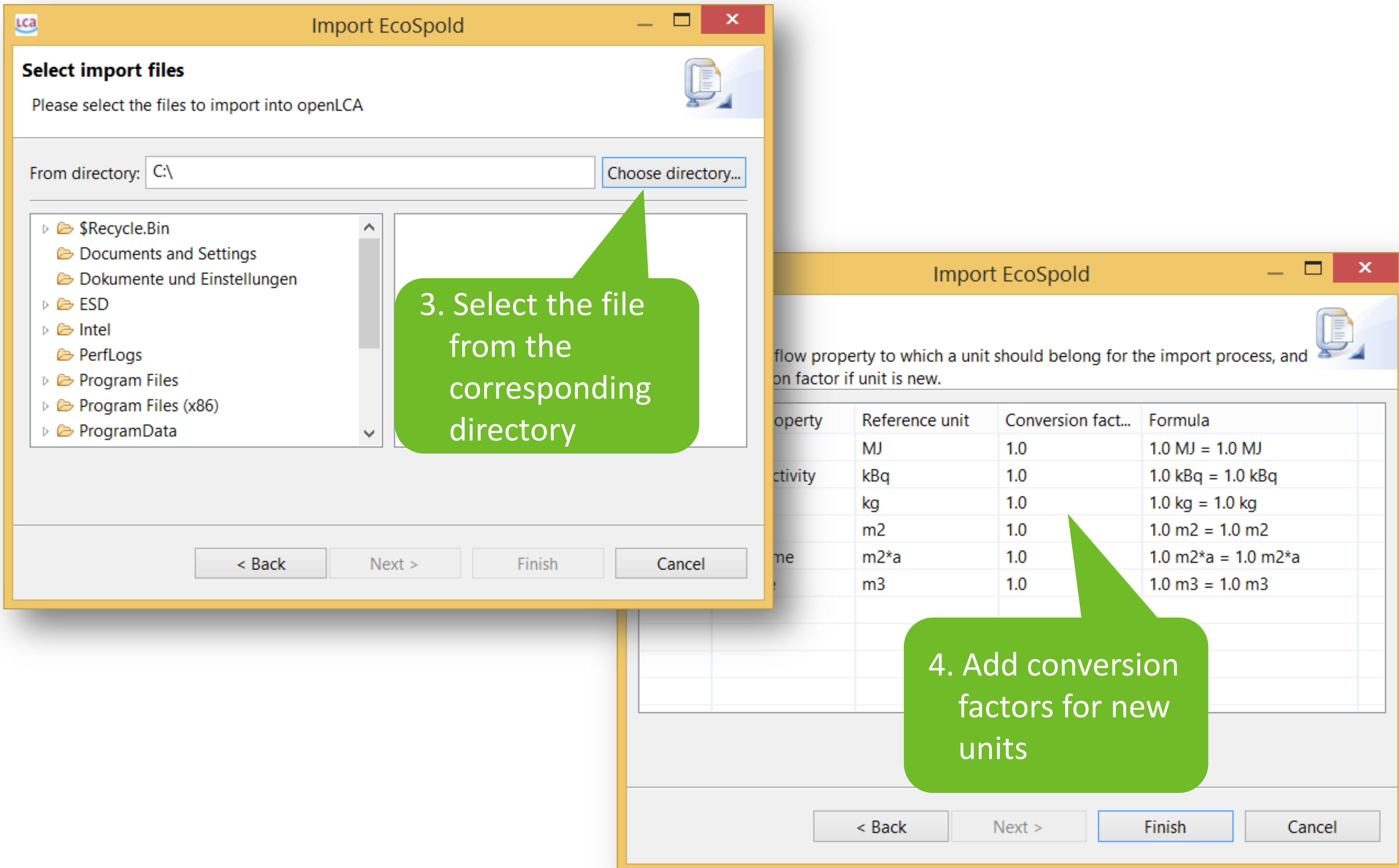
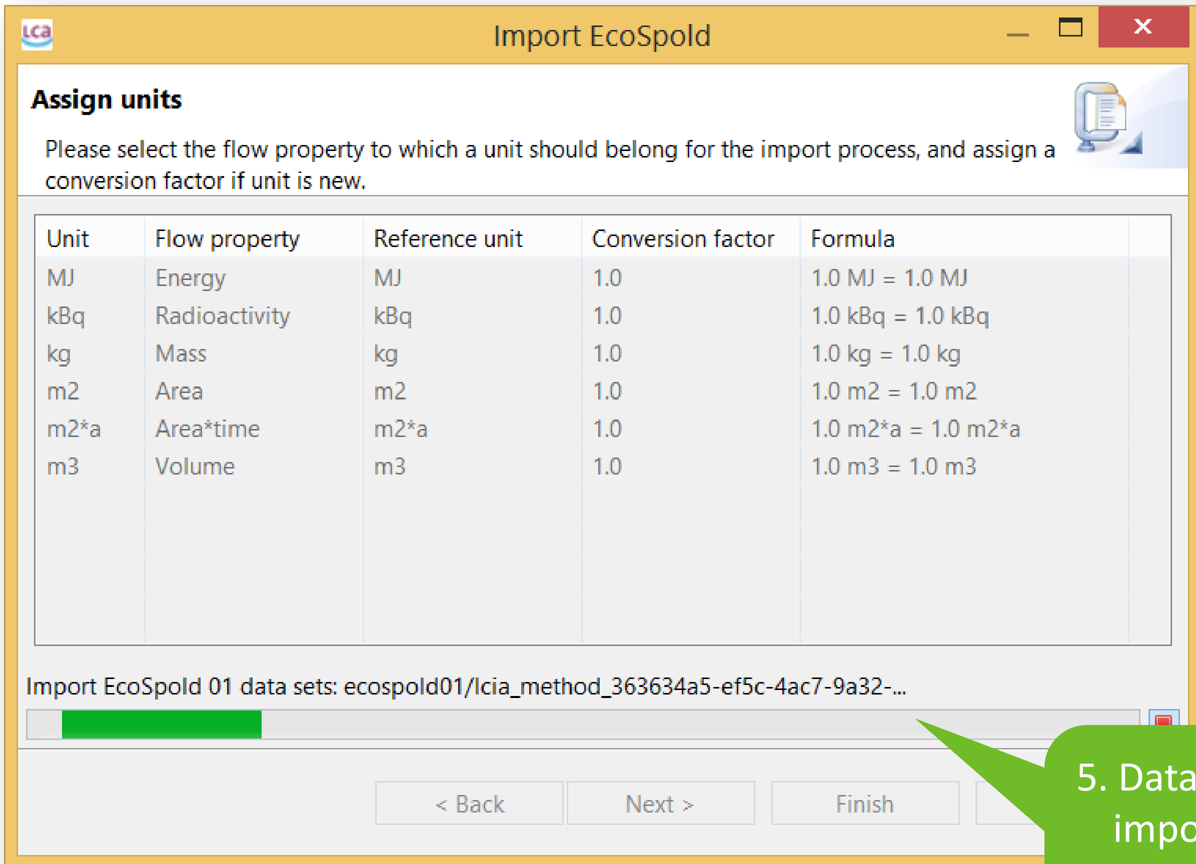
Import data sets



Import data sets (II)



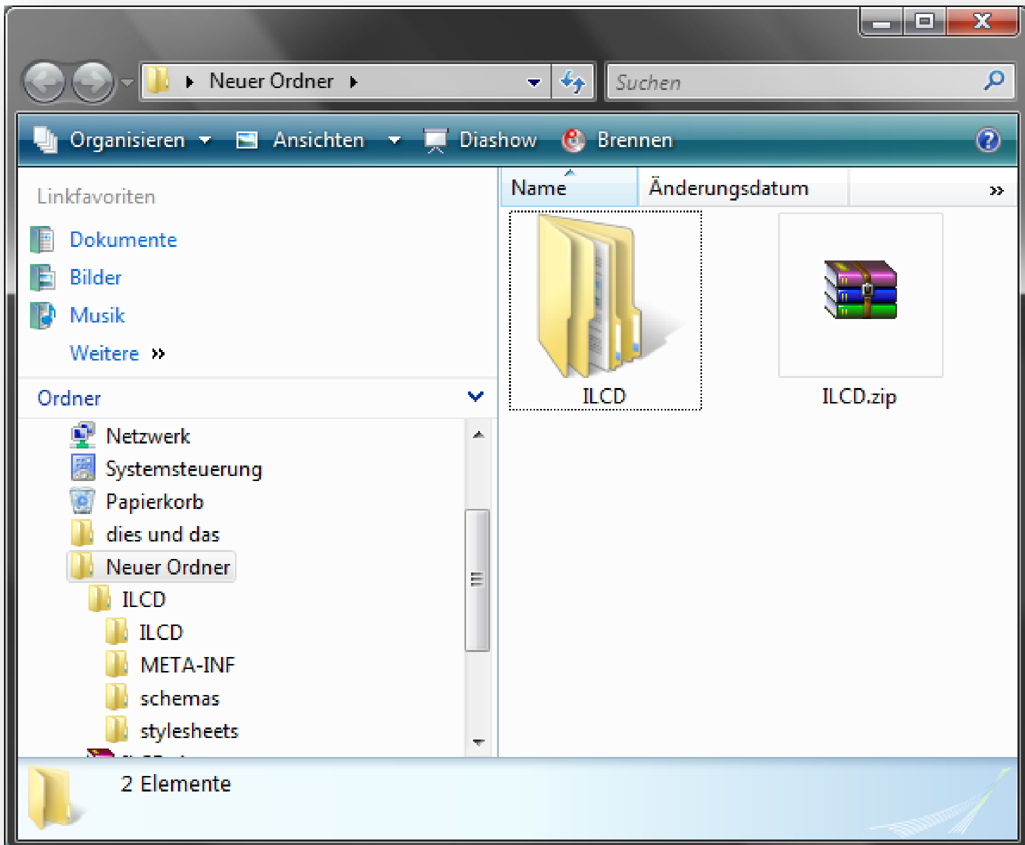
Import data sets (III)



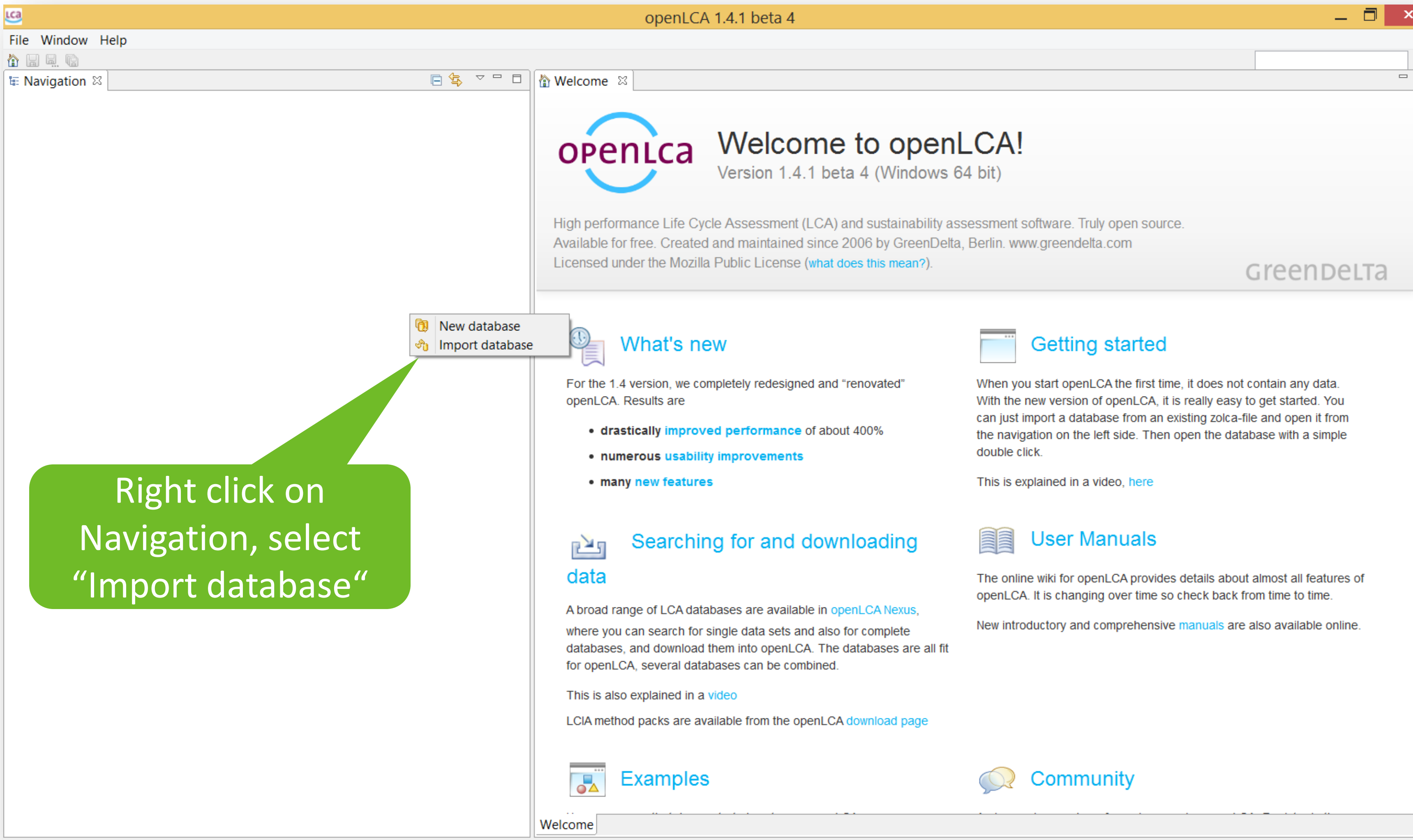
5. Data will be imported in your active database

ILCD import

- Data sets in ILCD must be imported as zip file:



openLCA database import



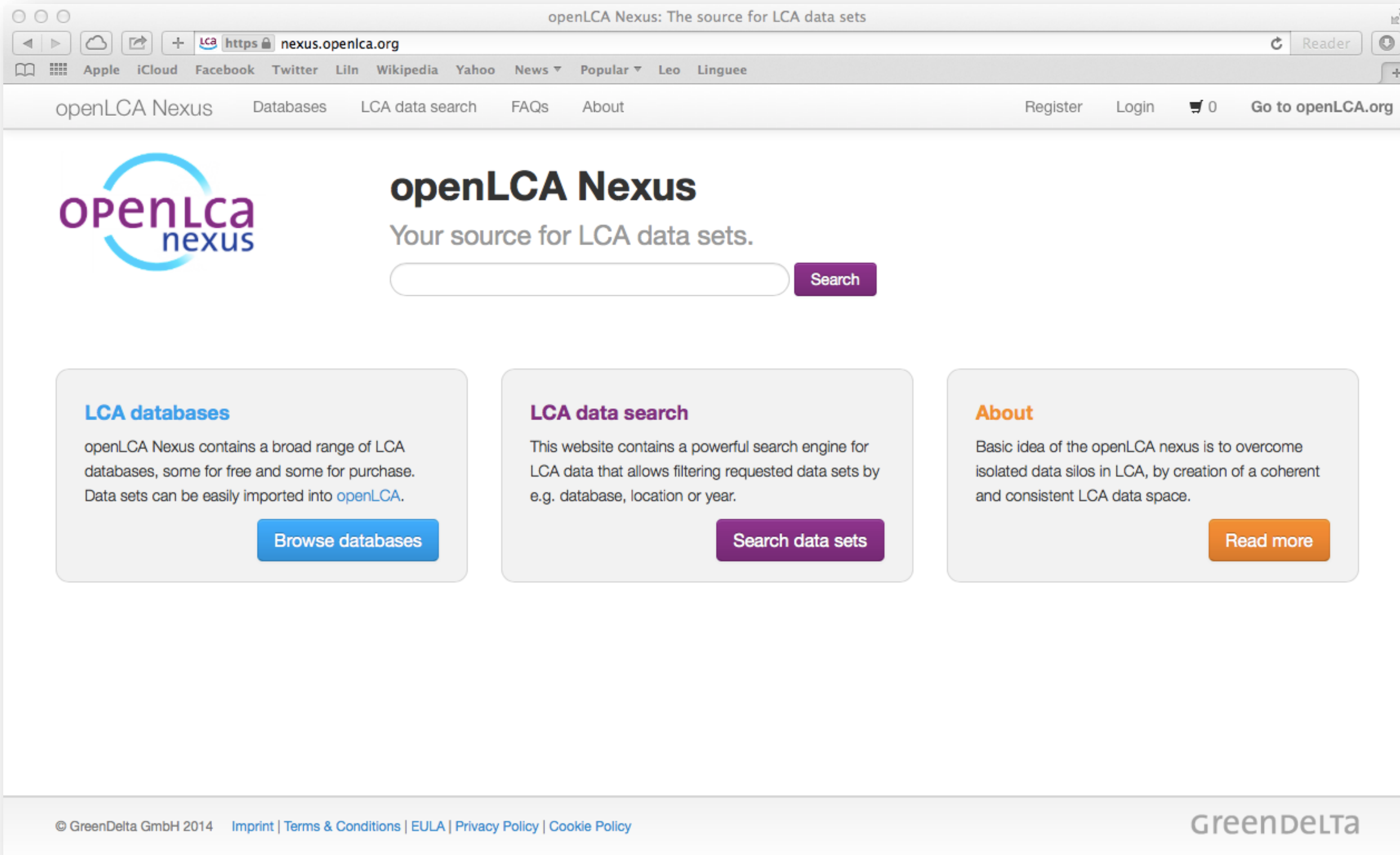
openLCA Nexus

- Search for and download data

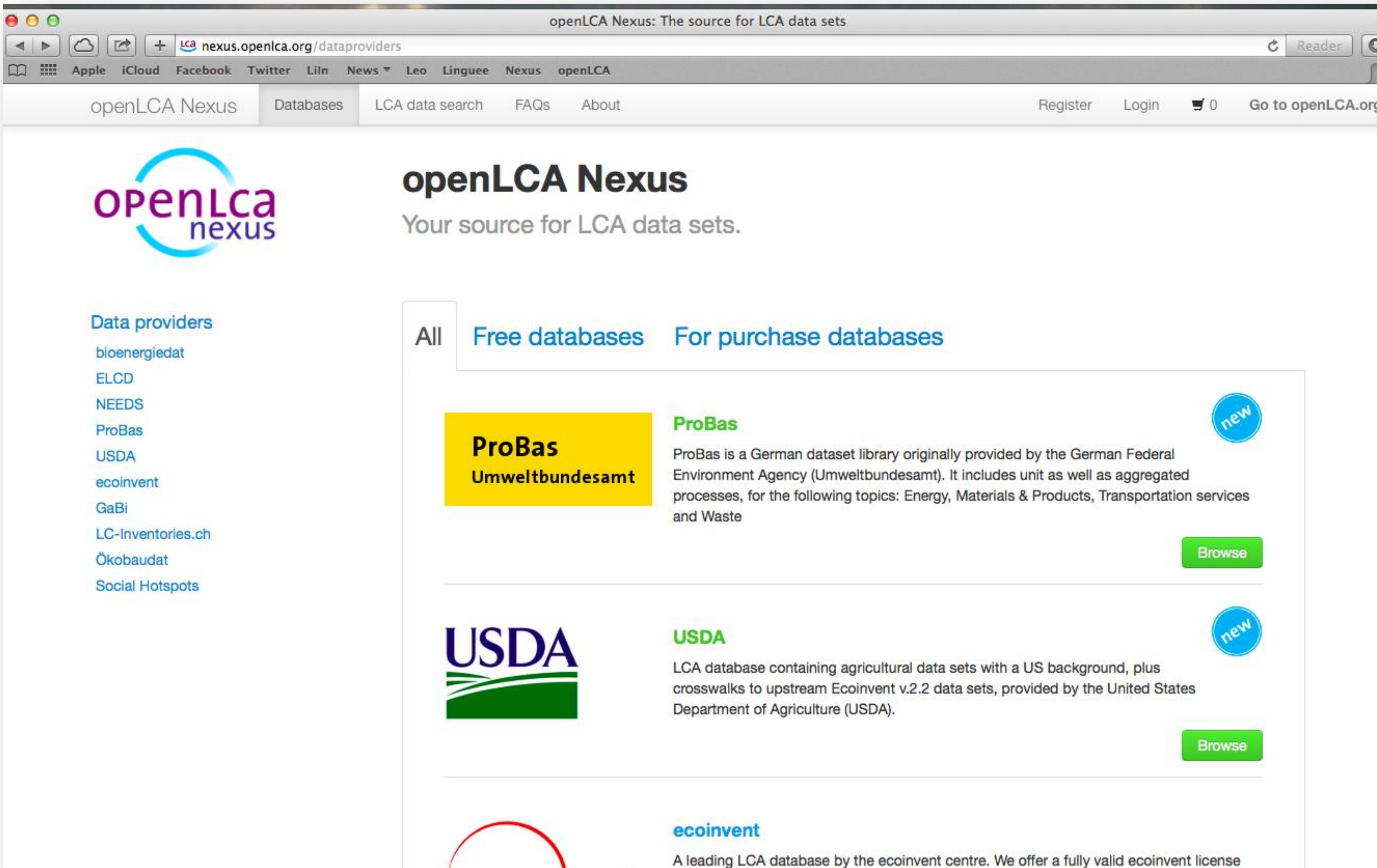
- Search for„provider, country, other location, category, price, and start of validity“ oder type search direct into search engine window

- Direct purchase/download of data fur use in openLCA

openLCA Nexus



openLCA Nexus



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openLCA Nexus

ecoinvent Centre

Ökobau.dat

ProBas Umweltbundesamt

www.LC-Inventories.ch

USDA

GaBi Database Content

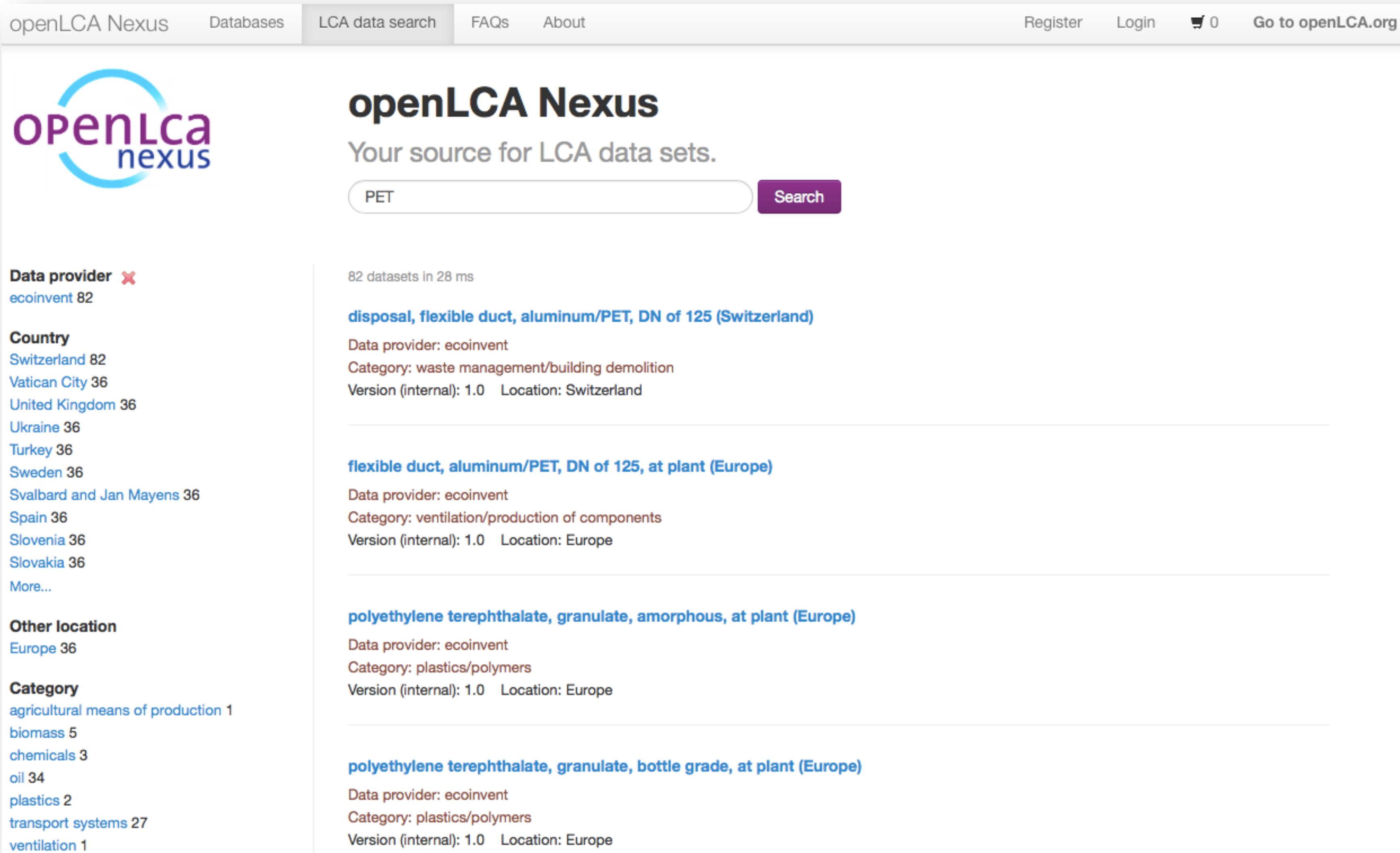
NEEDS

JRC EUROPEAN COMMISSION

social hotspots database

BIOENERGIEDAT

openLCA Nexus search engine



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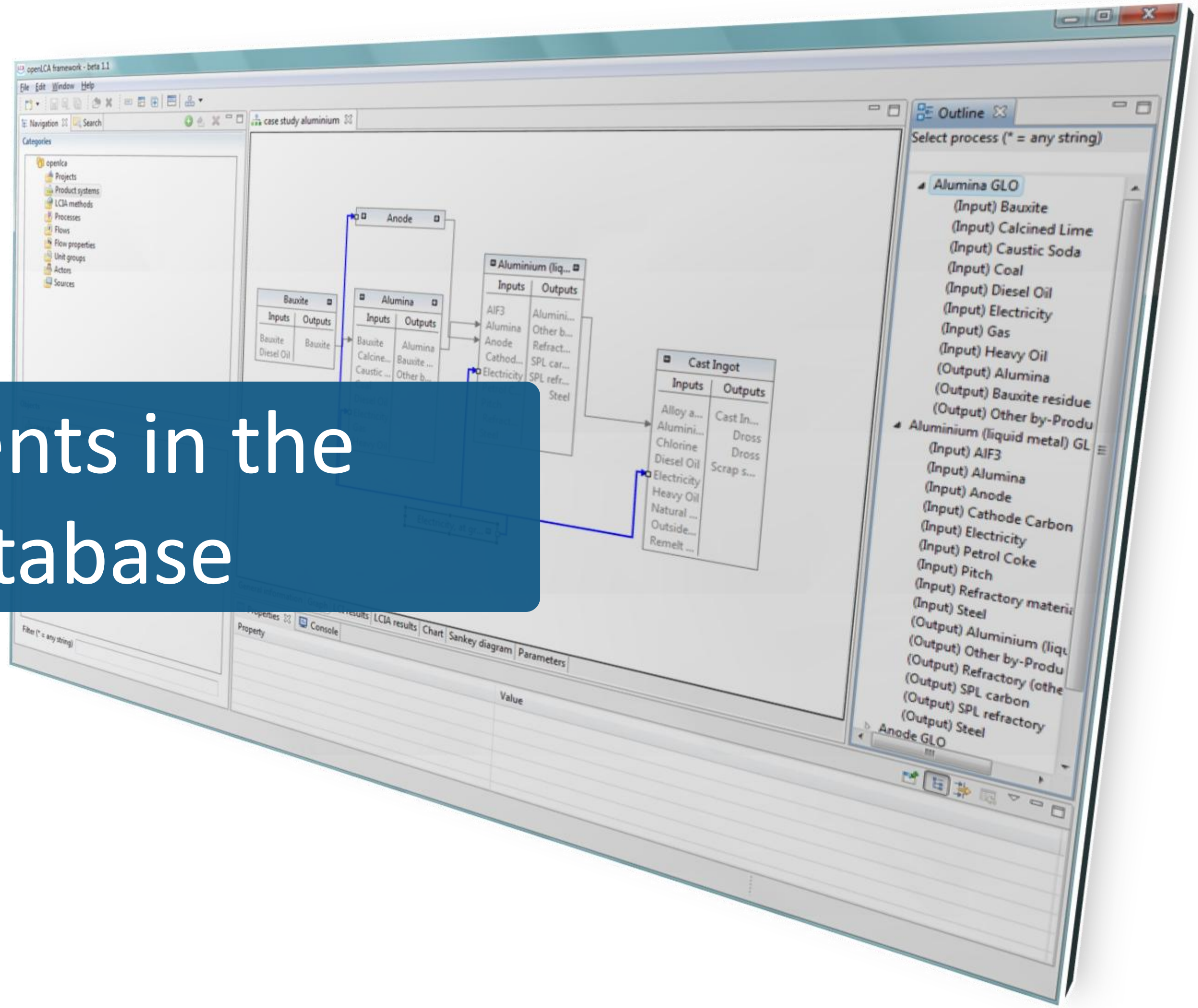
Elements in the database



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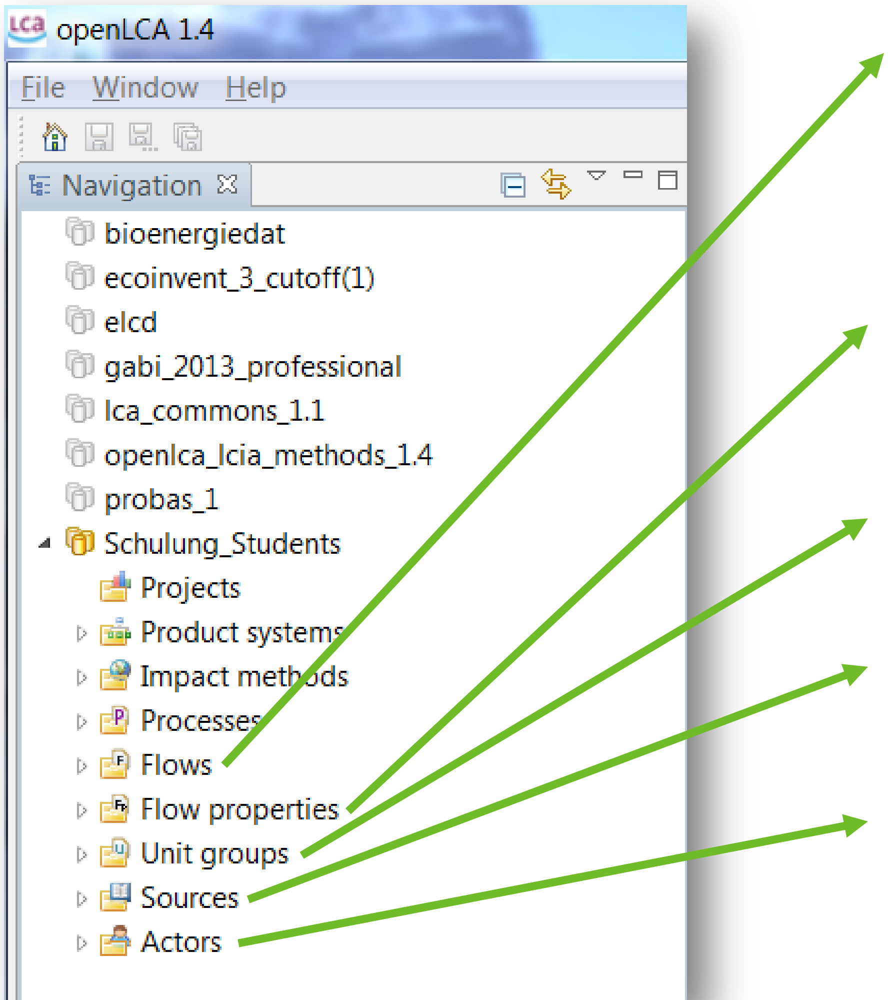
Database elements (I)



Flows: flow of products and materials

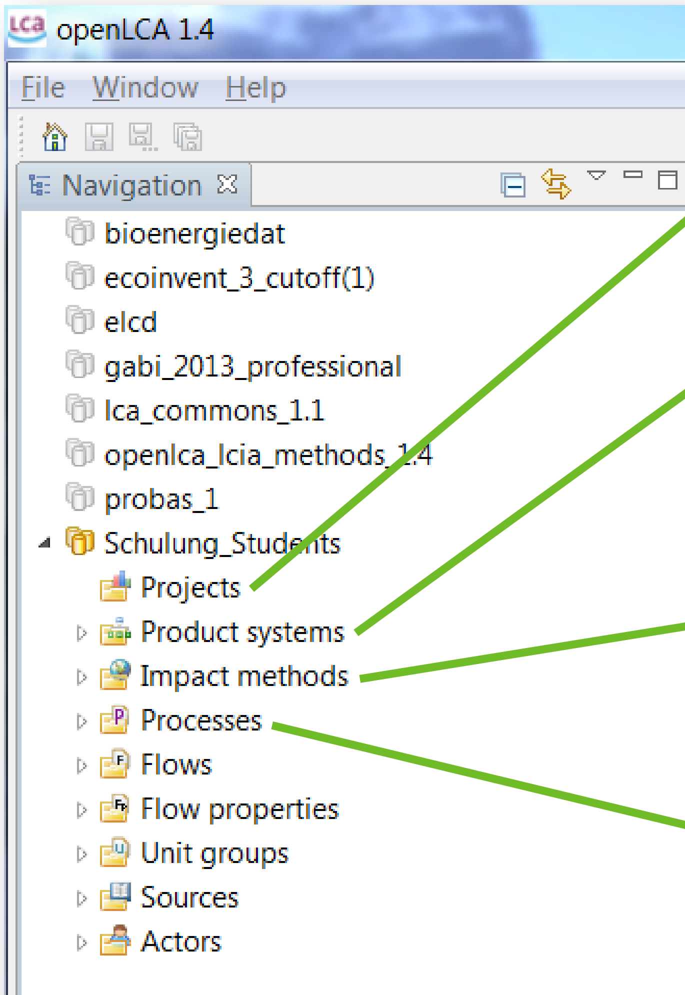
Flow properties: i.e. Length, Mass, etc

Unit groups: Groups of units

Sources: Literature

Actors: People who have provided data or modified models

Database elements (II)



Projects: comparison of numerous product systems

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

LCIA Methods: can be downloaded at openlca.org/downloads

Processes: Production or modification of materials/products

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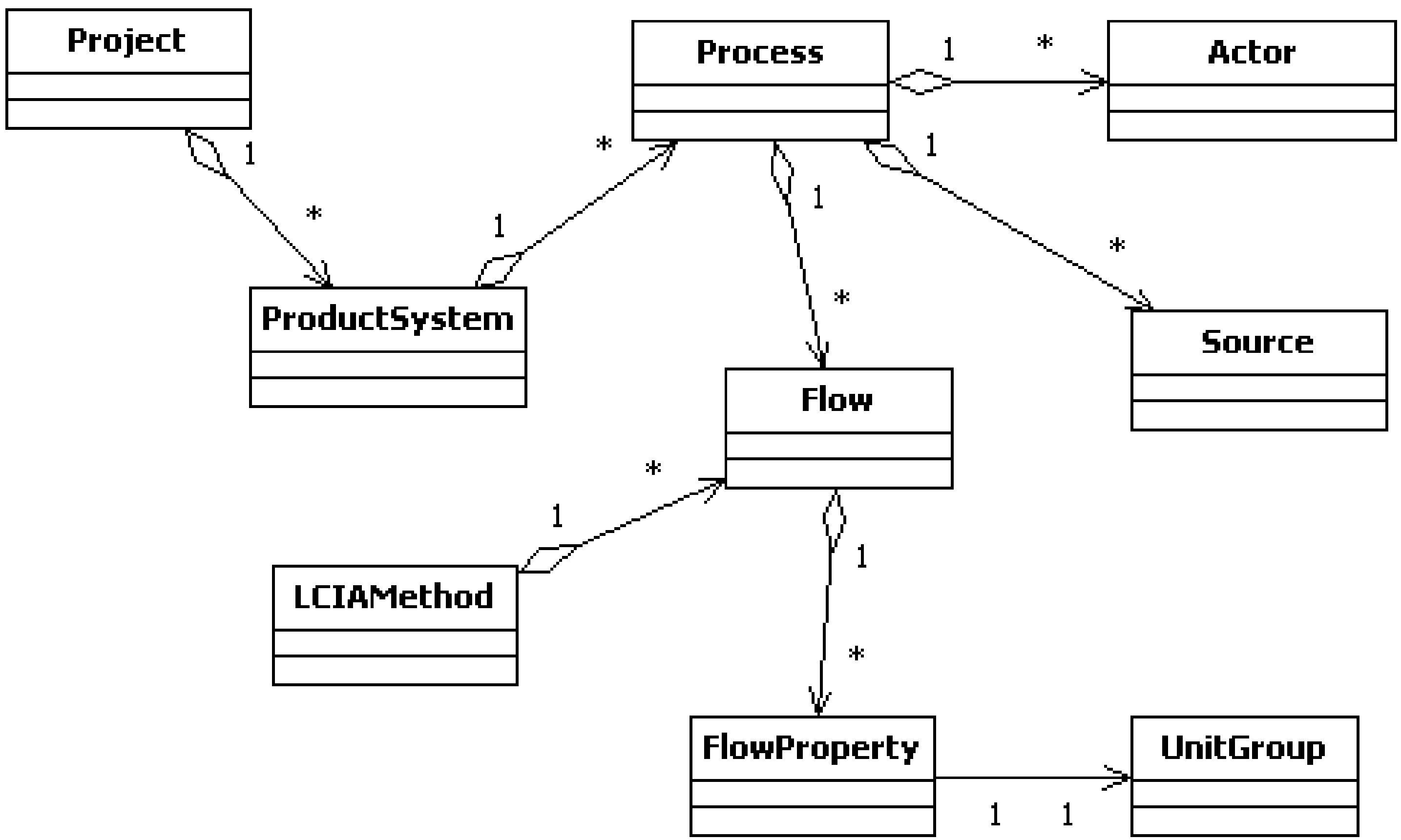
Element structure in openLCA



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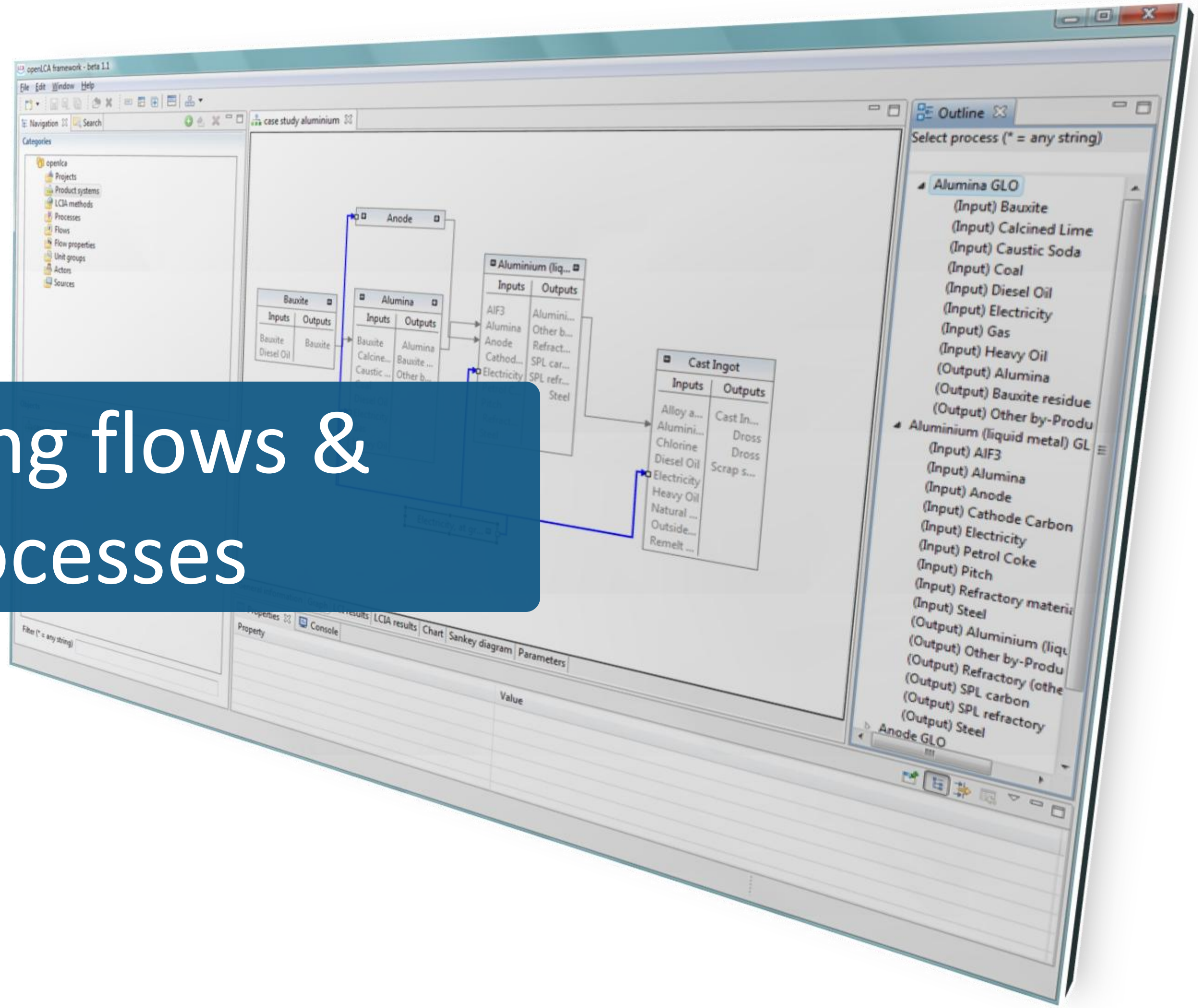
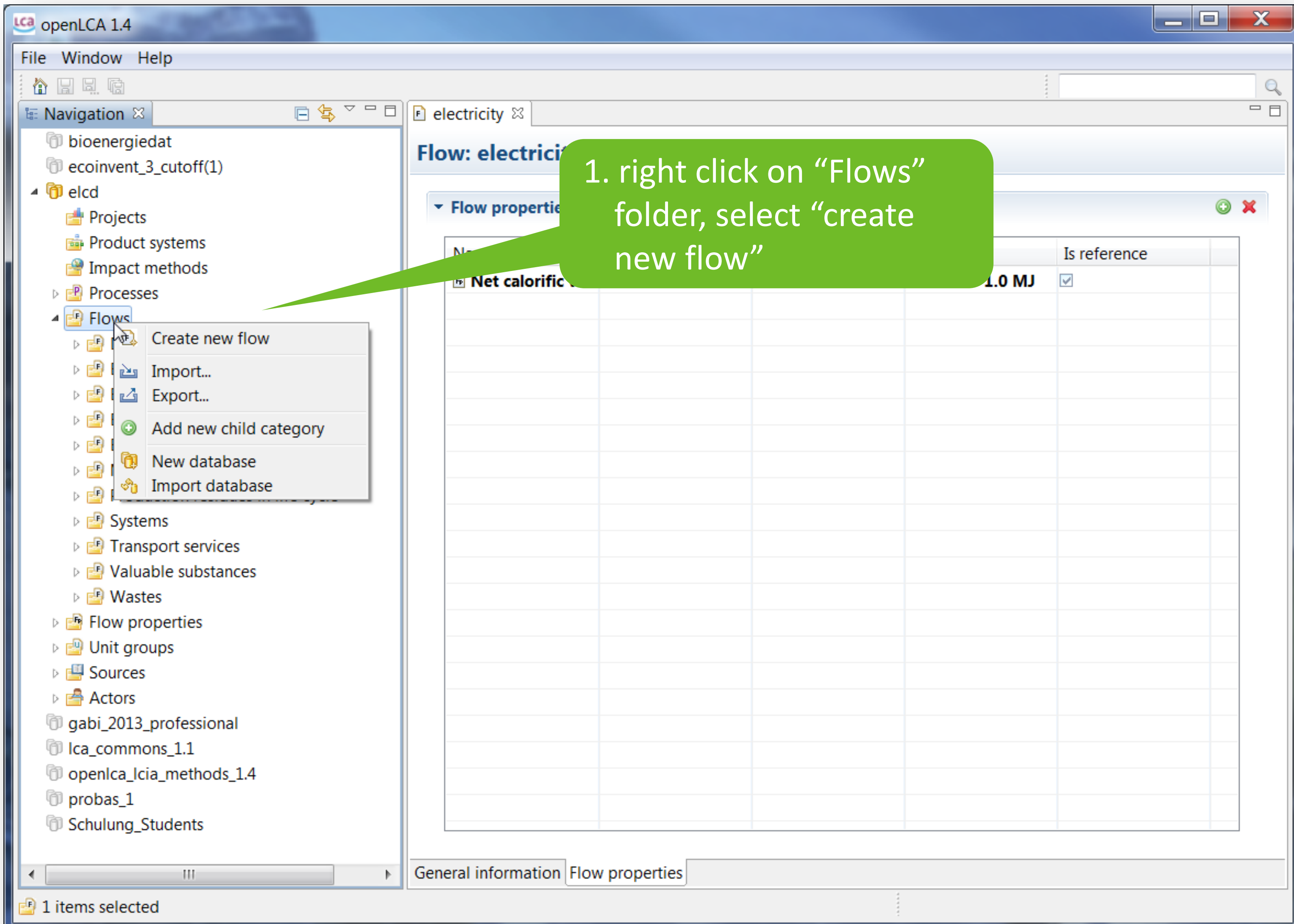
Creating flows & processes



Flows: Create new flow (I)



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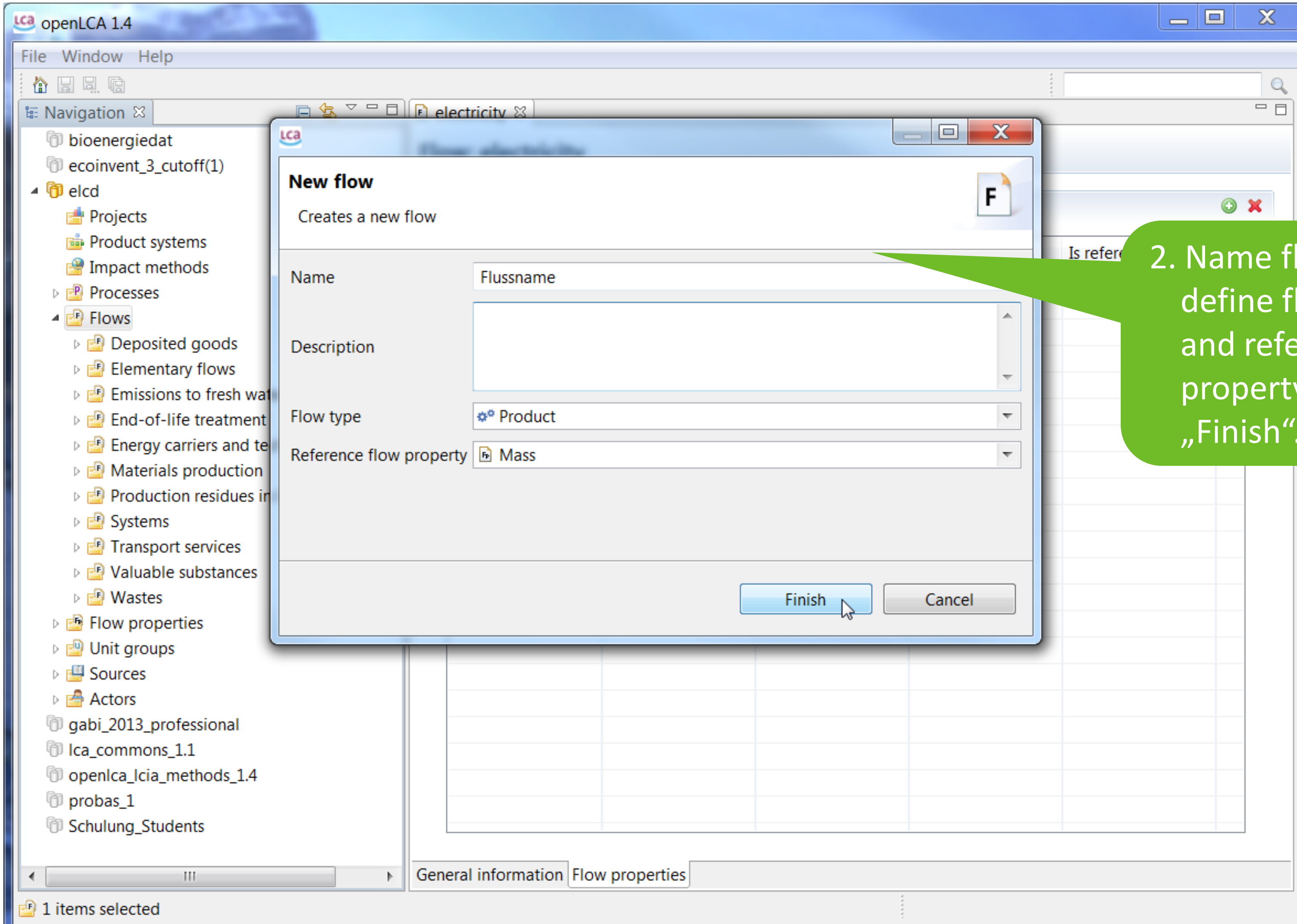
Flows: Create new flow (II)



2. Name flow and define flow type and reference flow property. Then click „Finish“.

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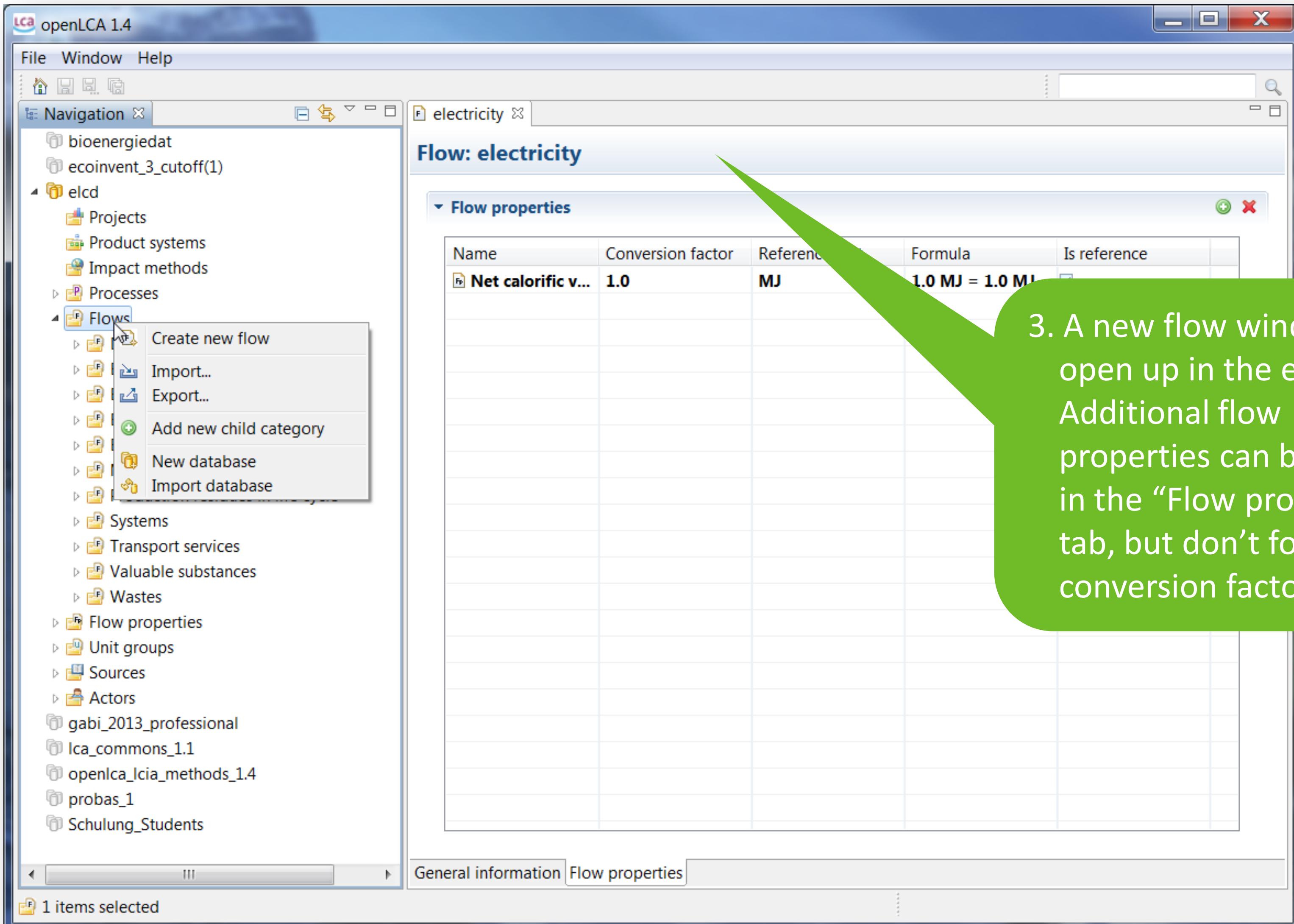
Flows: Create new flow (III)



3. A new flow window will open up in the editor. Additional flow properties can be added in the "Flow properties" tab, but don't forget the conversion factor!

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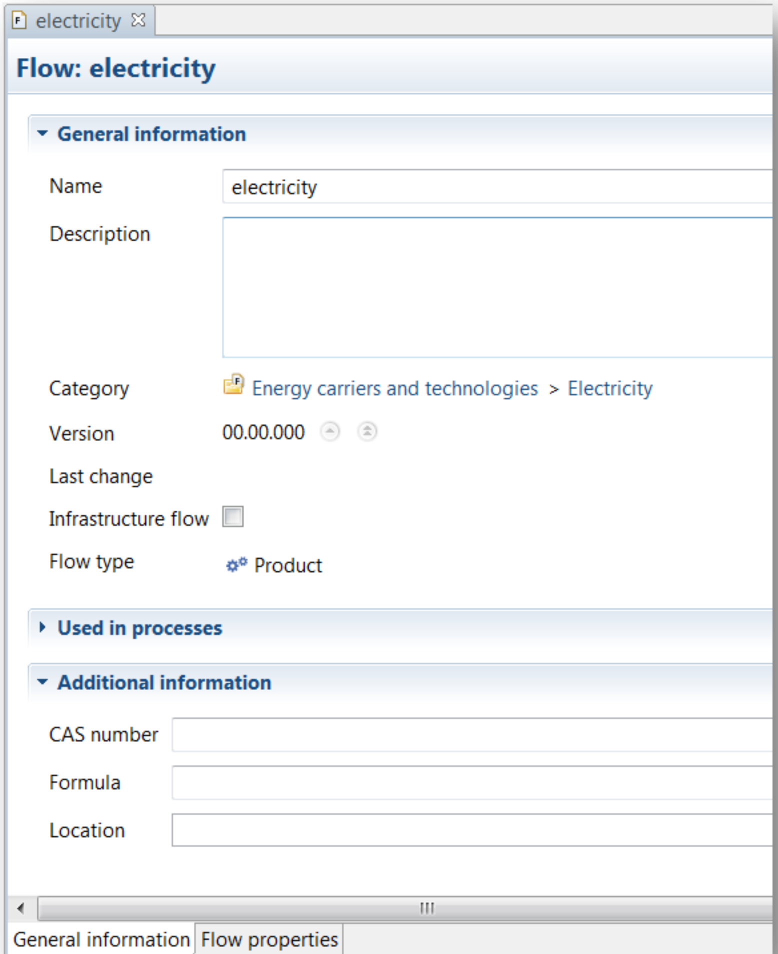
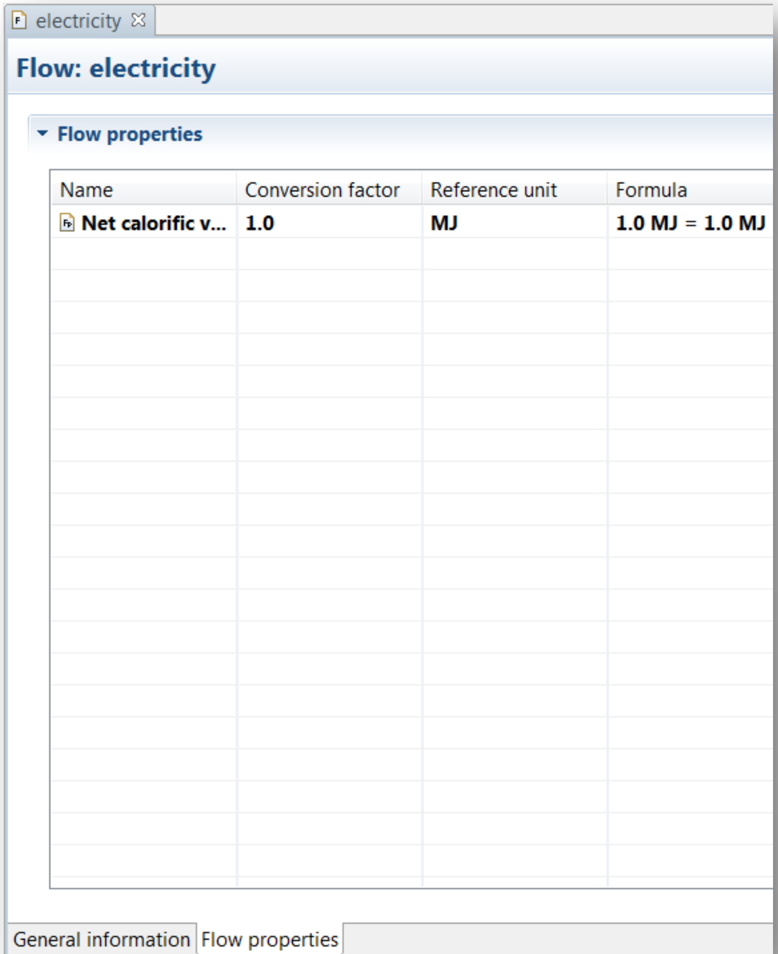
Flow: Information & properties





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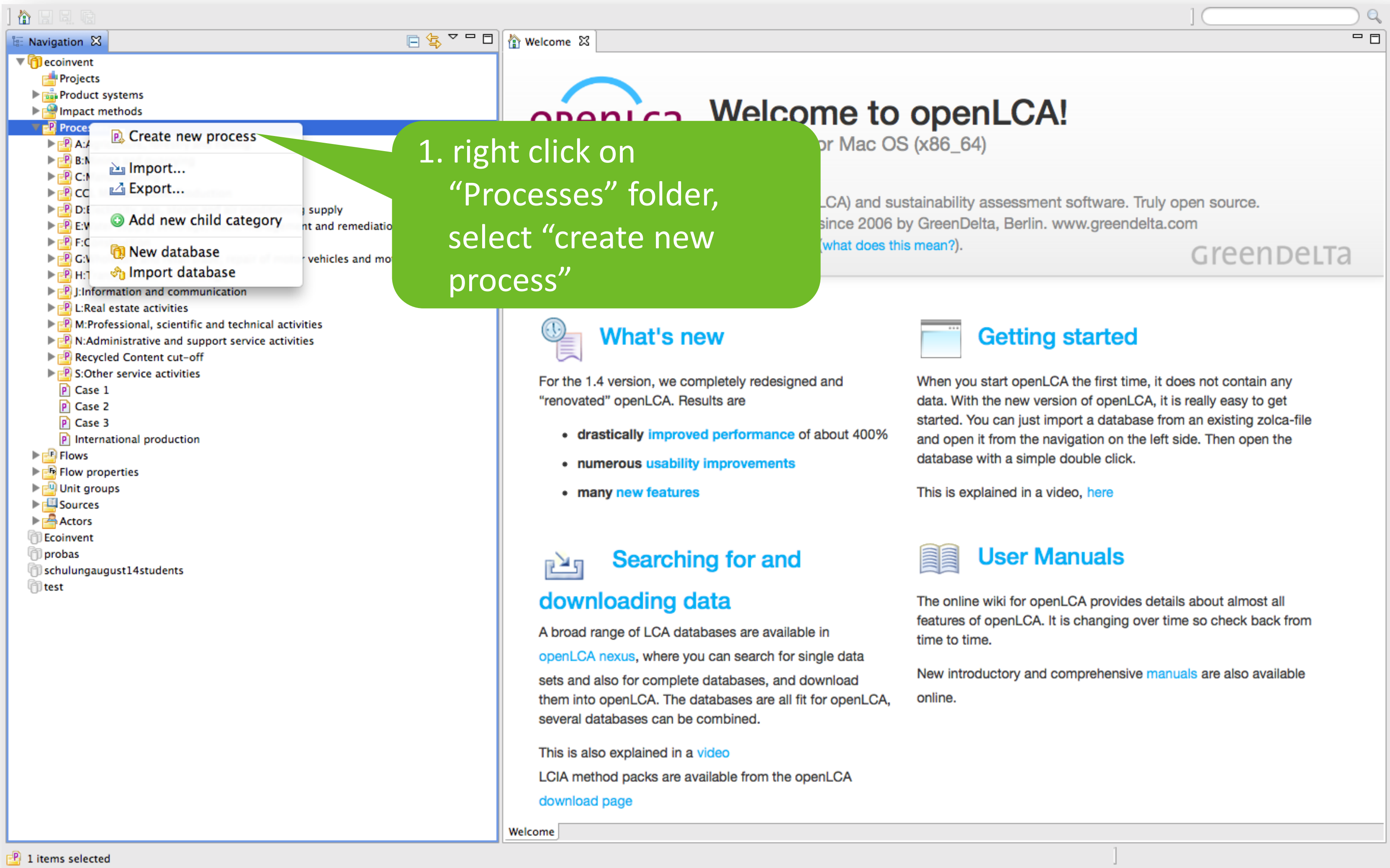
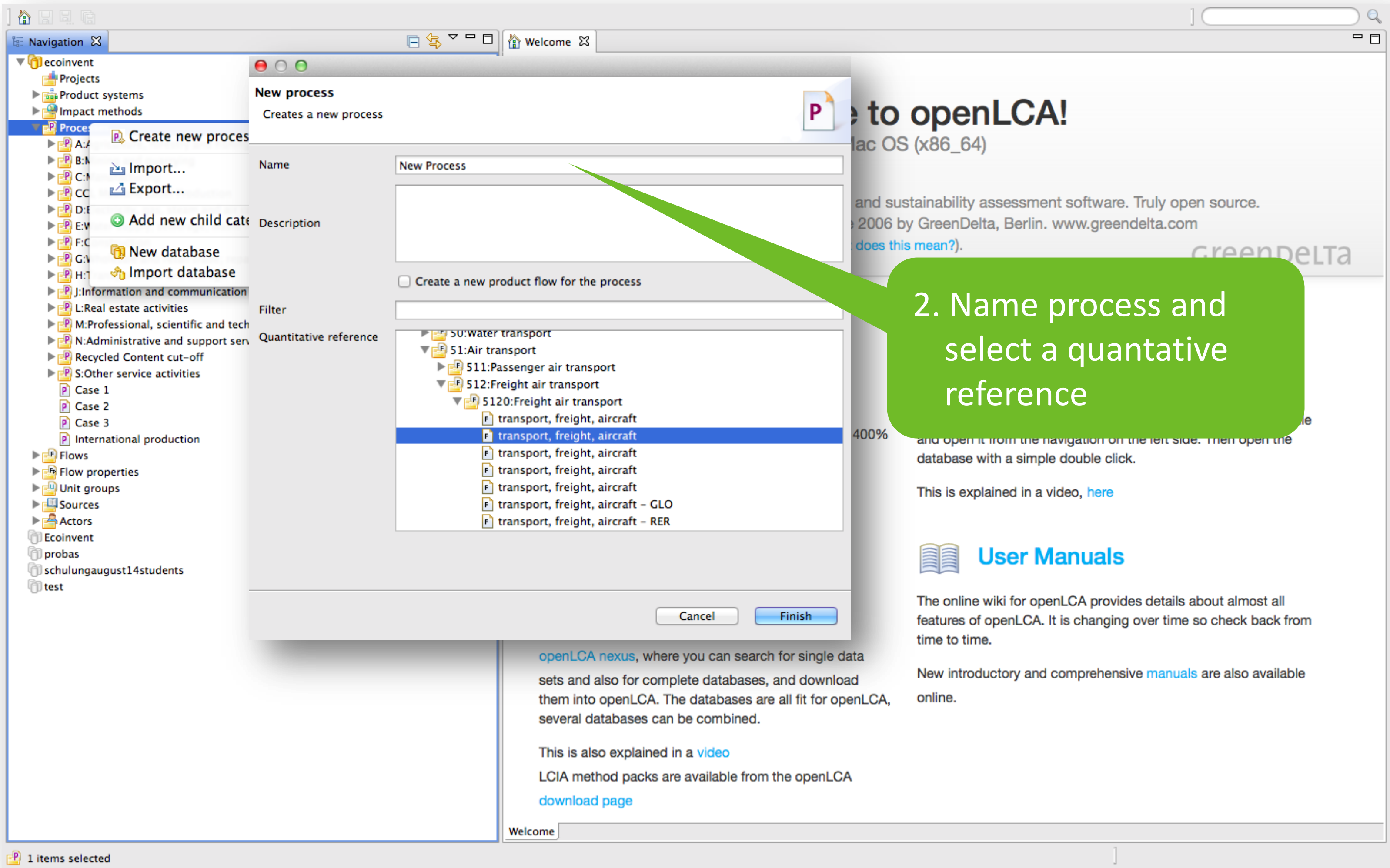
Process: Create new process (I)



1. right click on “Processes” folder, select “create new process”

Process: Create new process (II)



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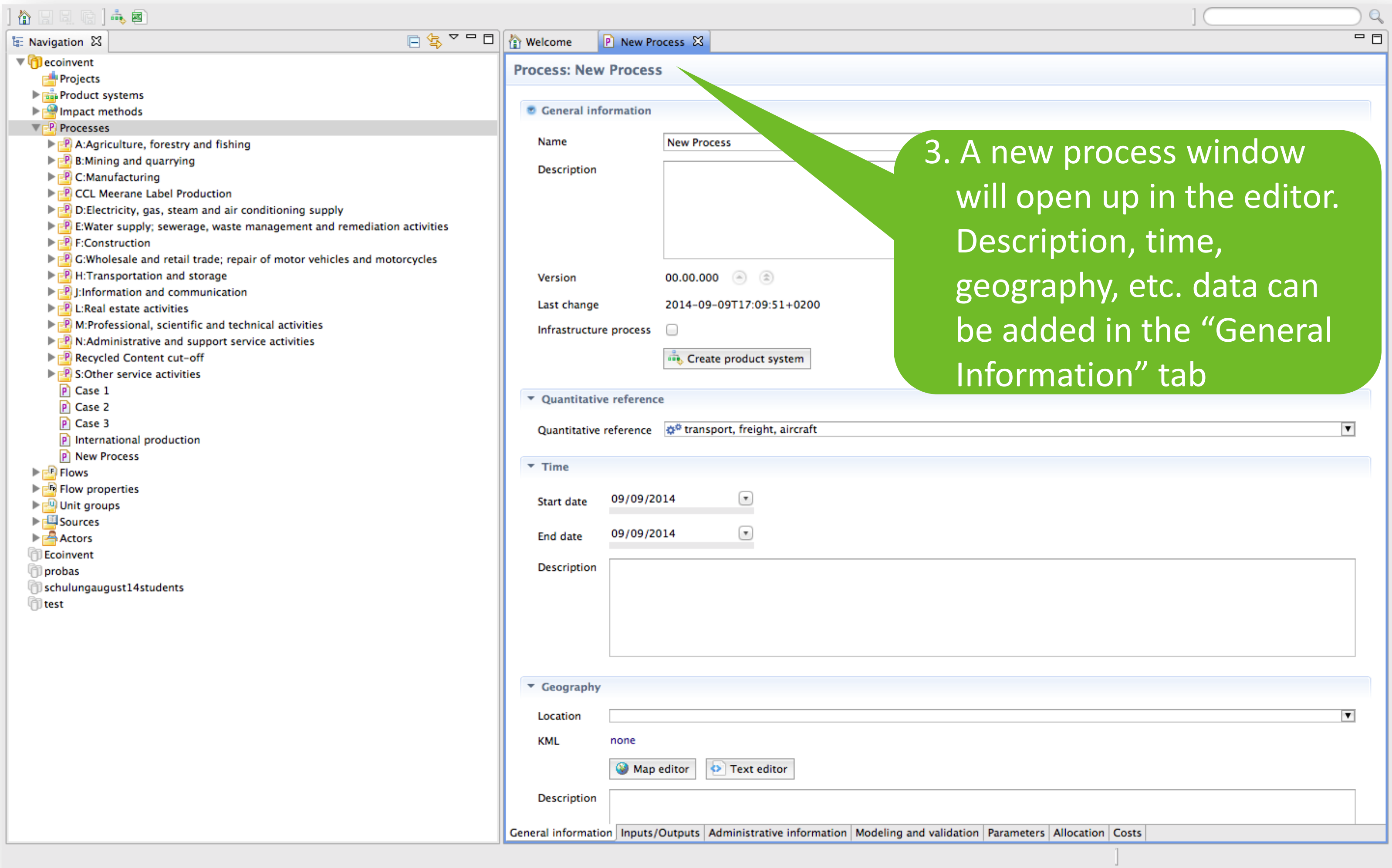
Process: Create new process (III)



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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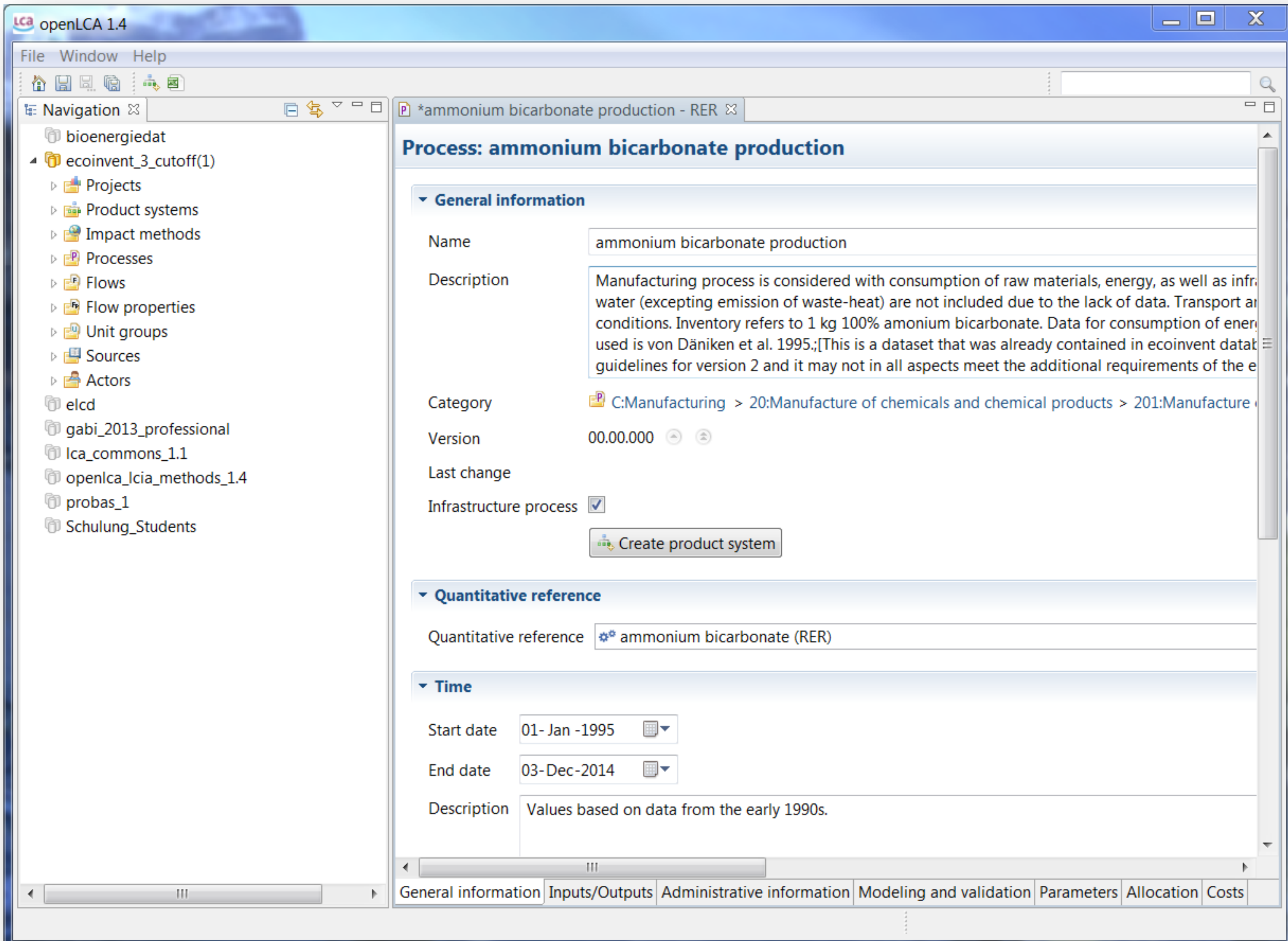
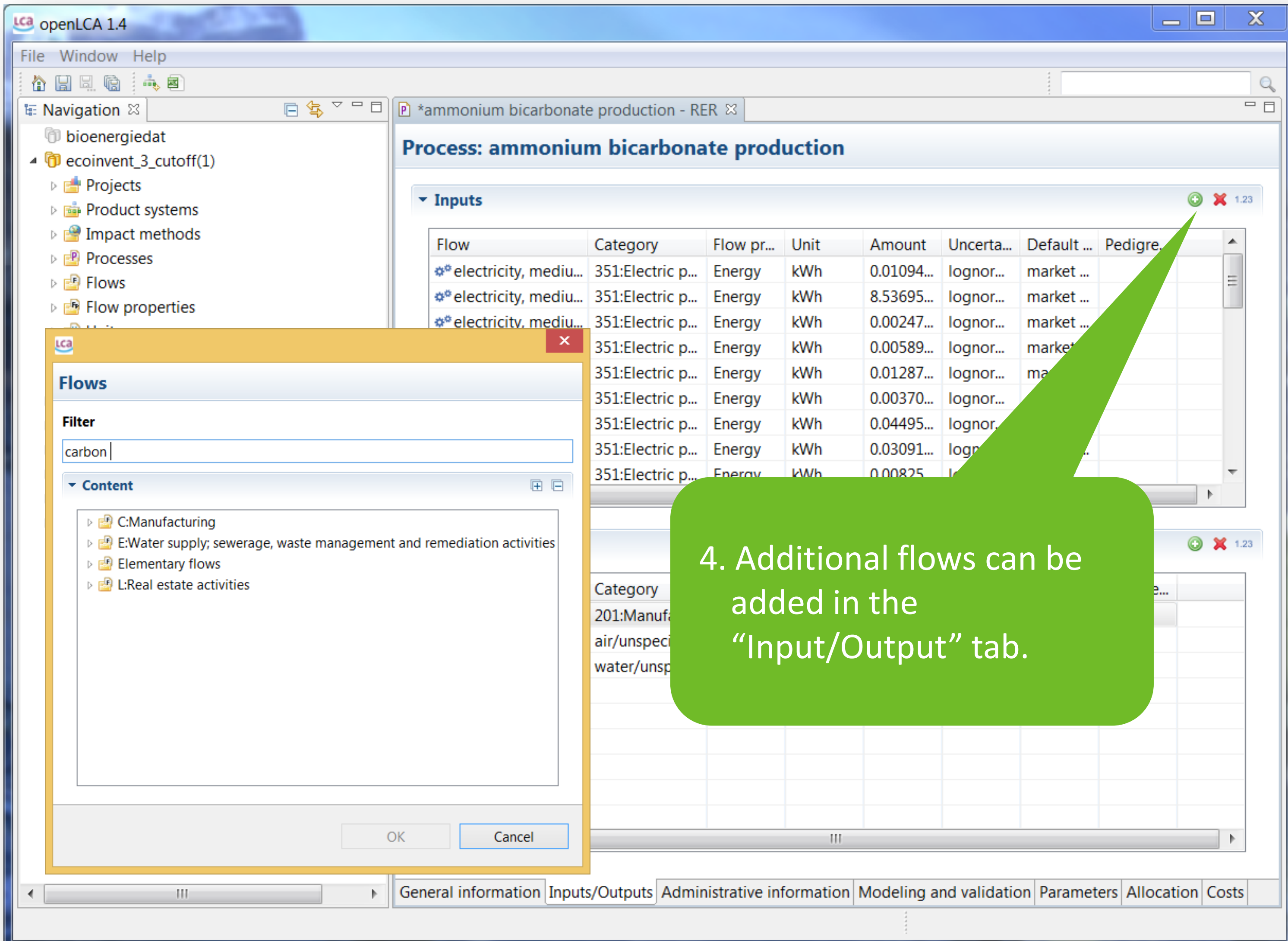
Process: General information



Process: Inputs/Outputs



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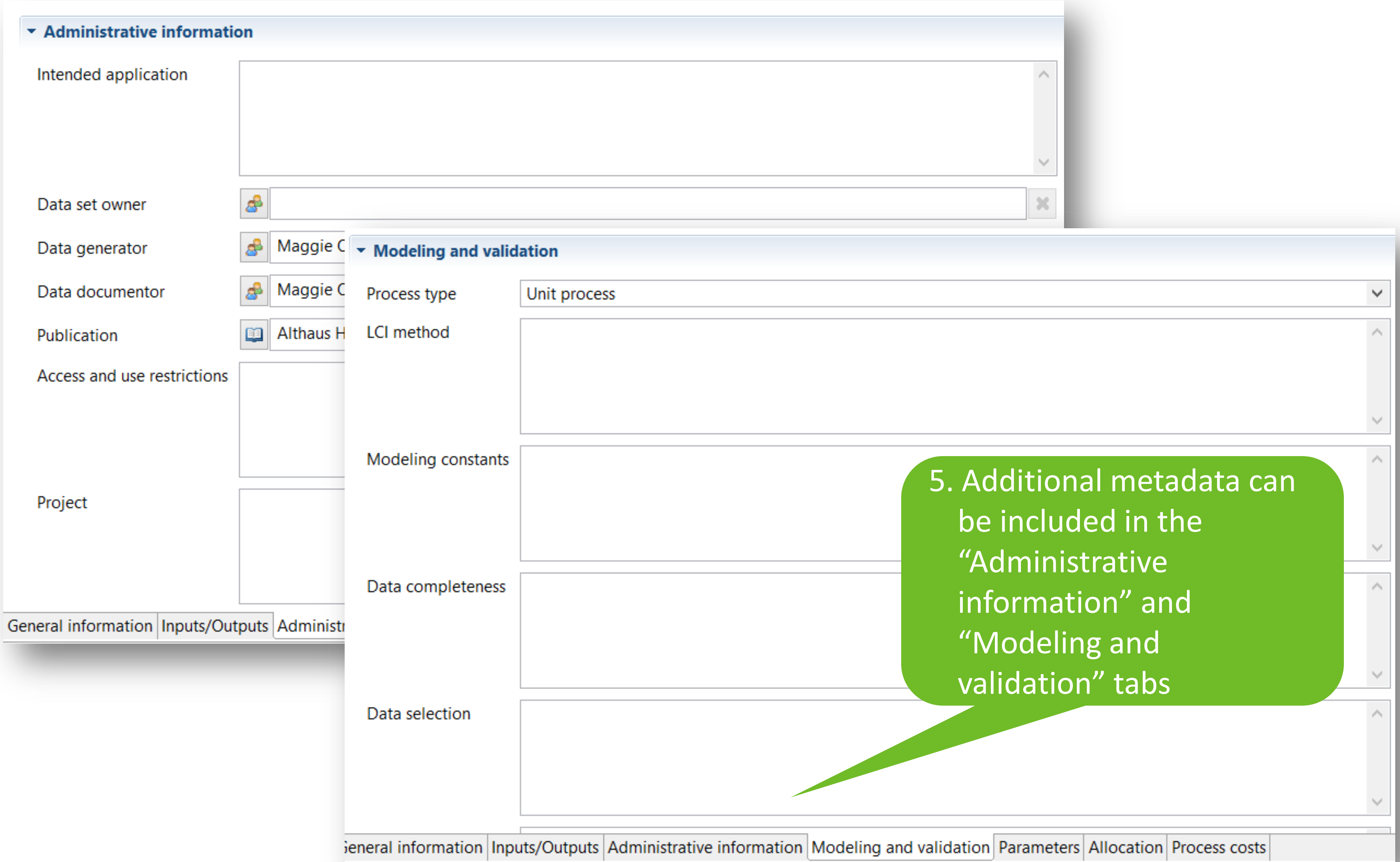
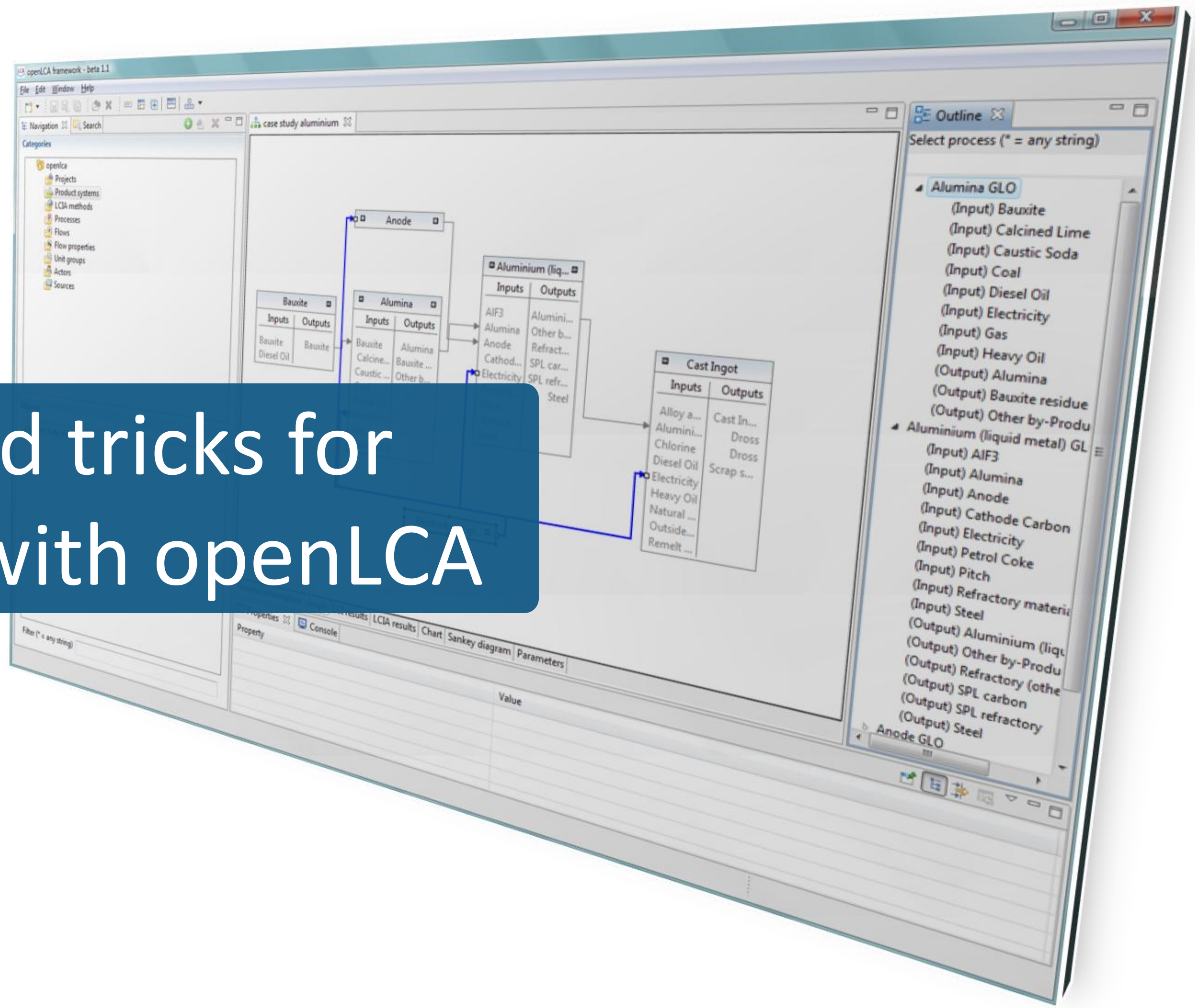
Process: Administrative Info. & Modeling and validation





Tips and tricks for working with openLCA

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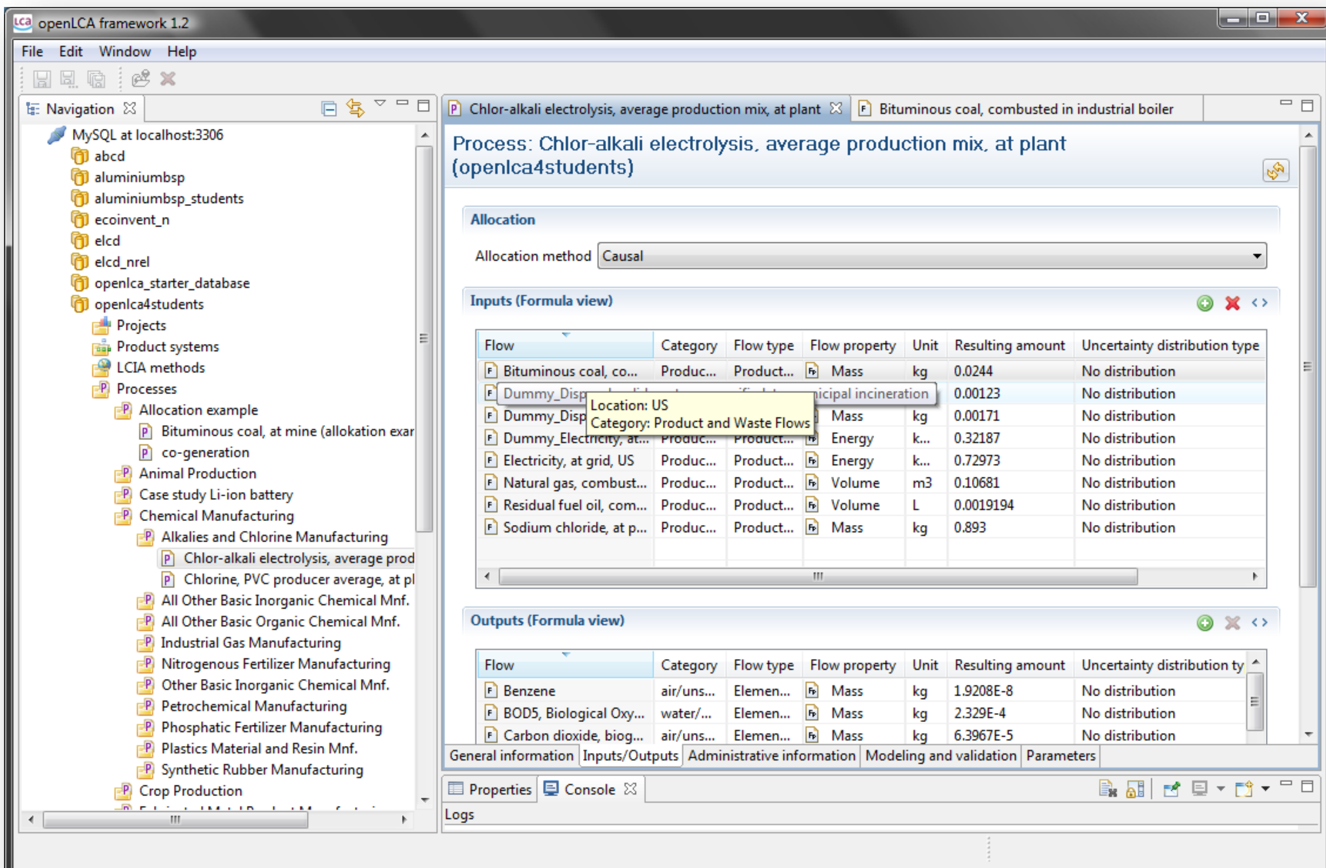
Basic commands

- 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: 

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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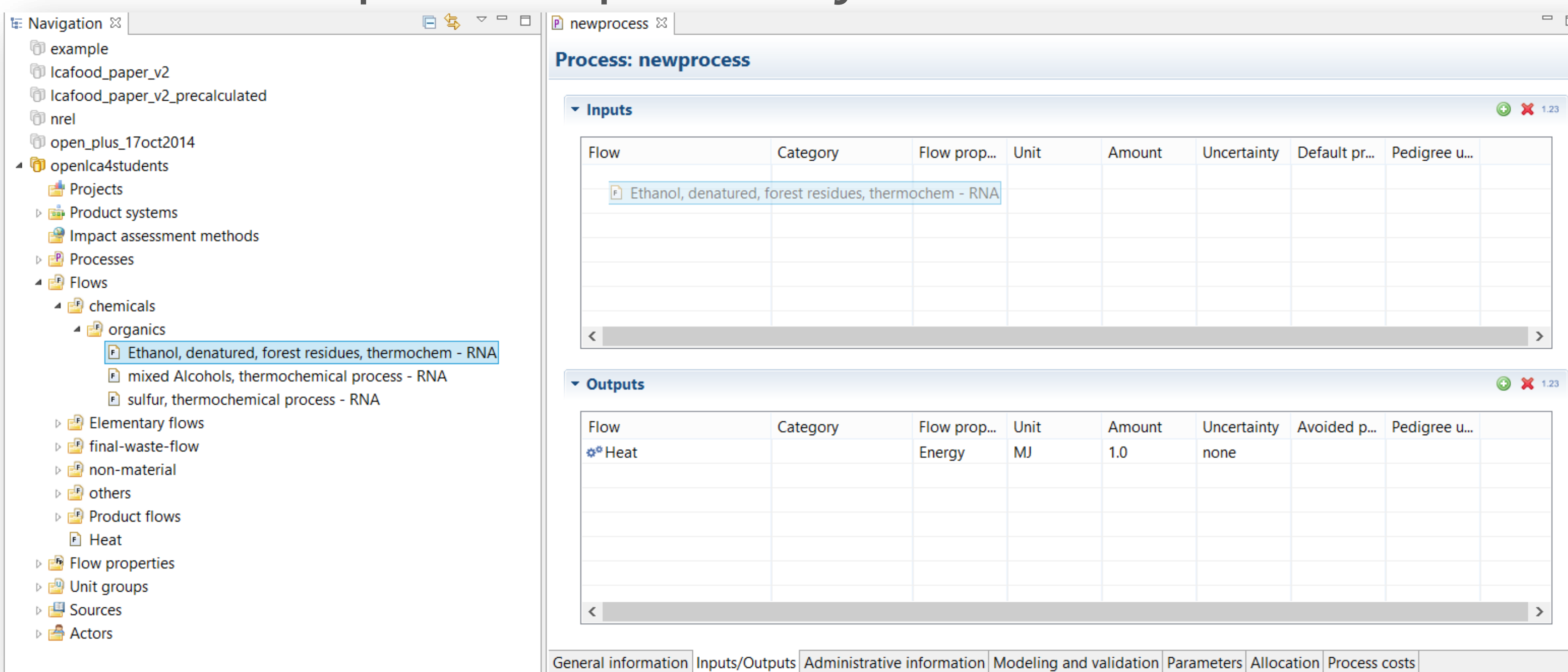
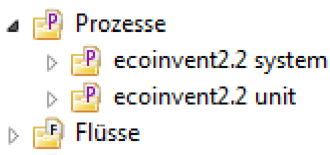
Basic commands

- 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



Folder structure

- Divide system and unit processes



- Divide processes from different databases in one openLCA database
- 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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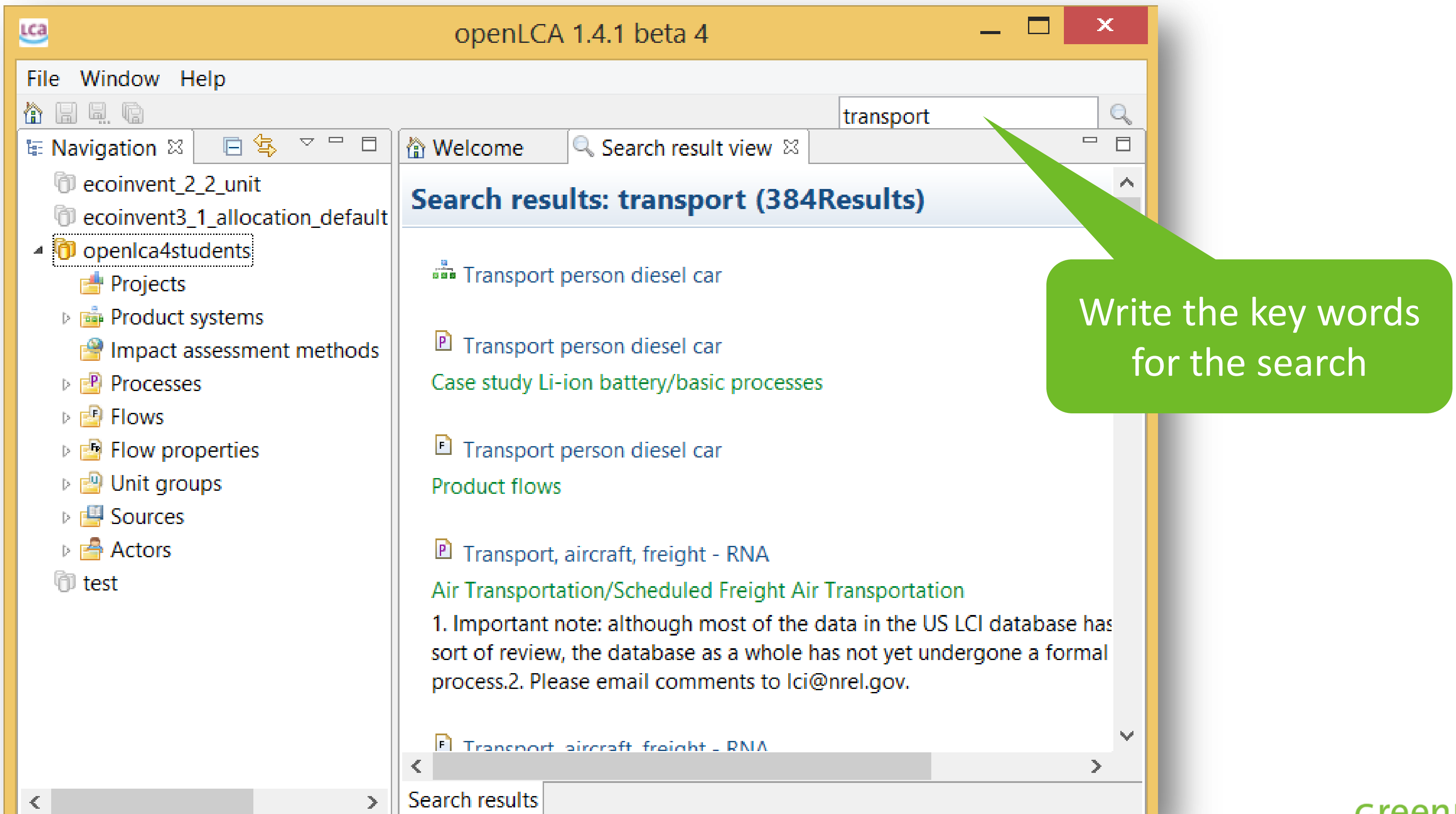
Windows

- 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

Search

- Search any element from the database



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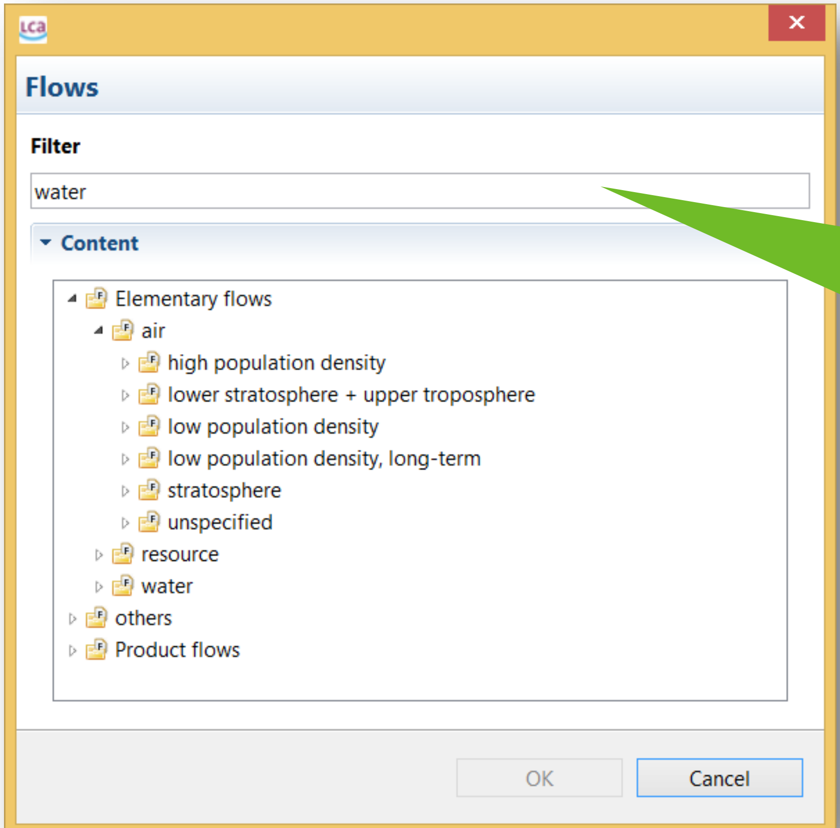
Filter

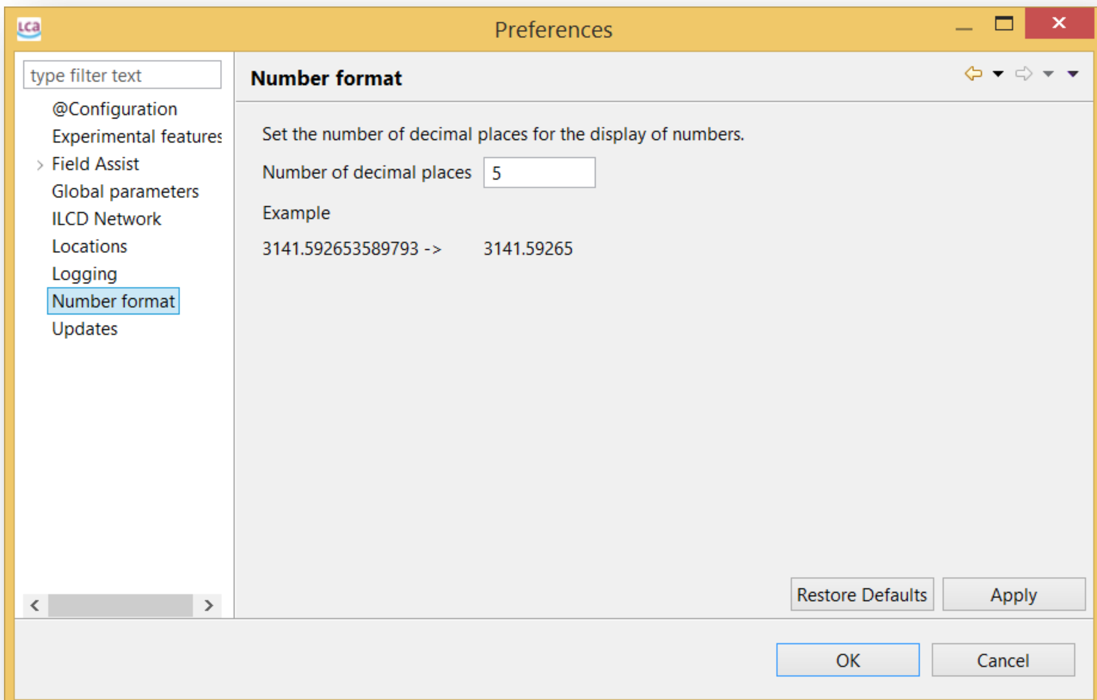
- The "add new" editors contain a filter for facilitating the search of the desired element



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

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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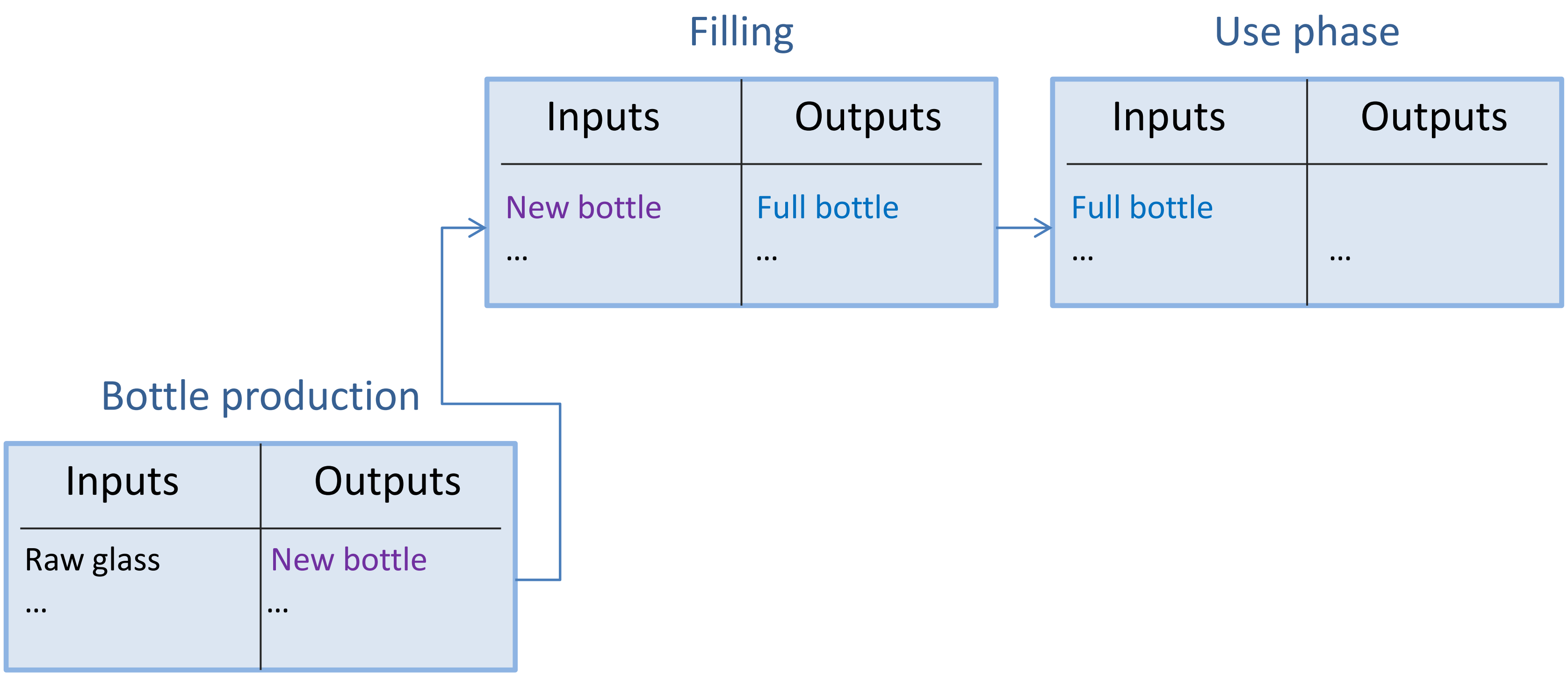
Modeling with product flows

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



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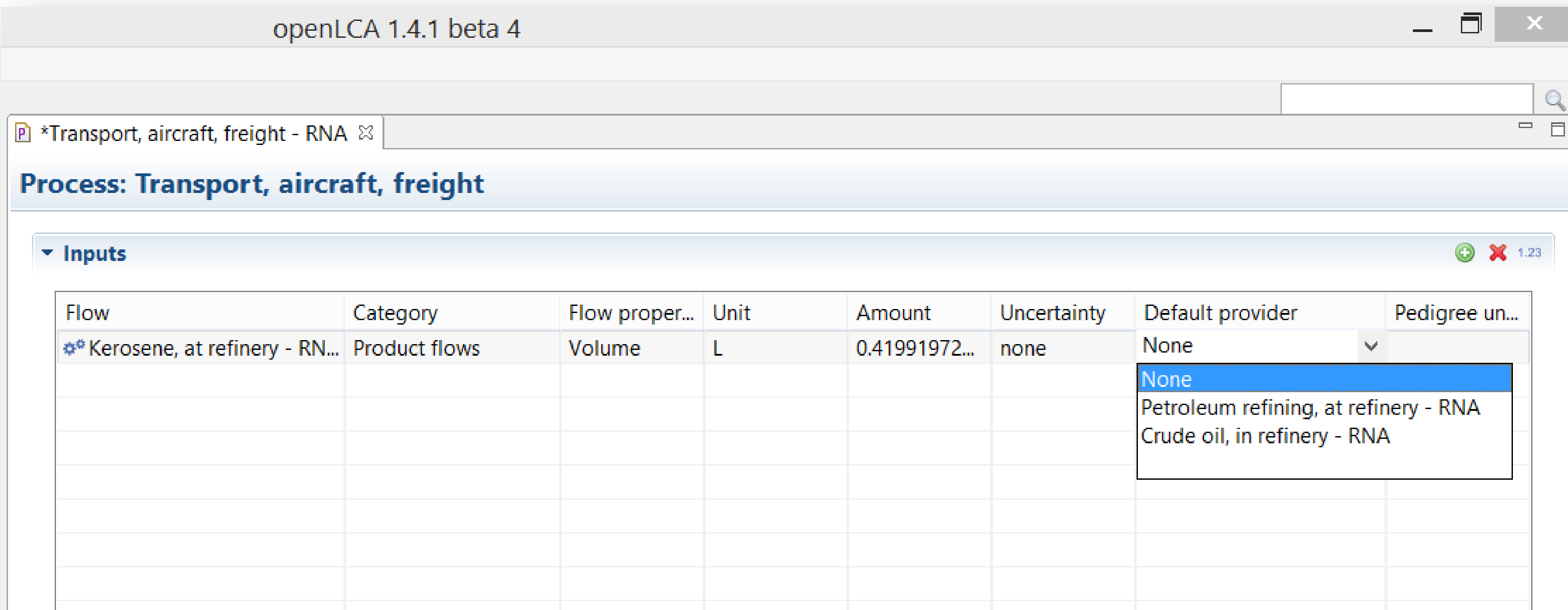
Modeling with product flows

- The default provider can be set for each exchange



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Modeling of waste

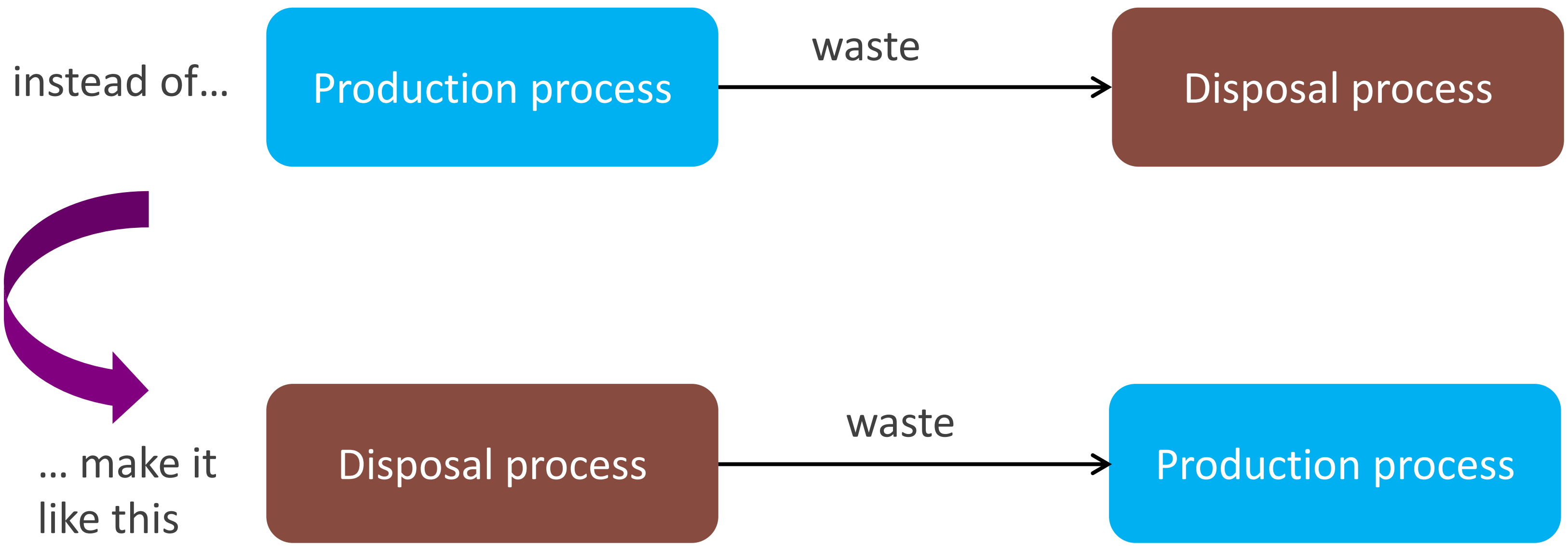
- "Reverse direction": Usual (production processes) is that donations to another process are something of value for the receiving process

- Disposal processes aim to eliminate the receiving flow

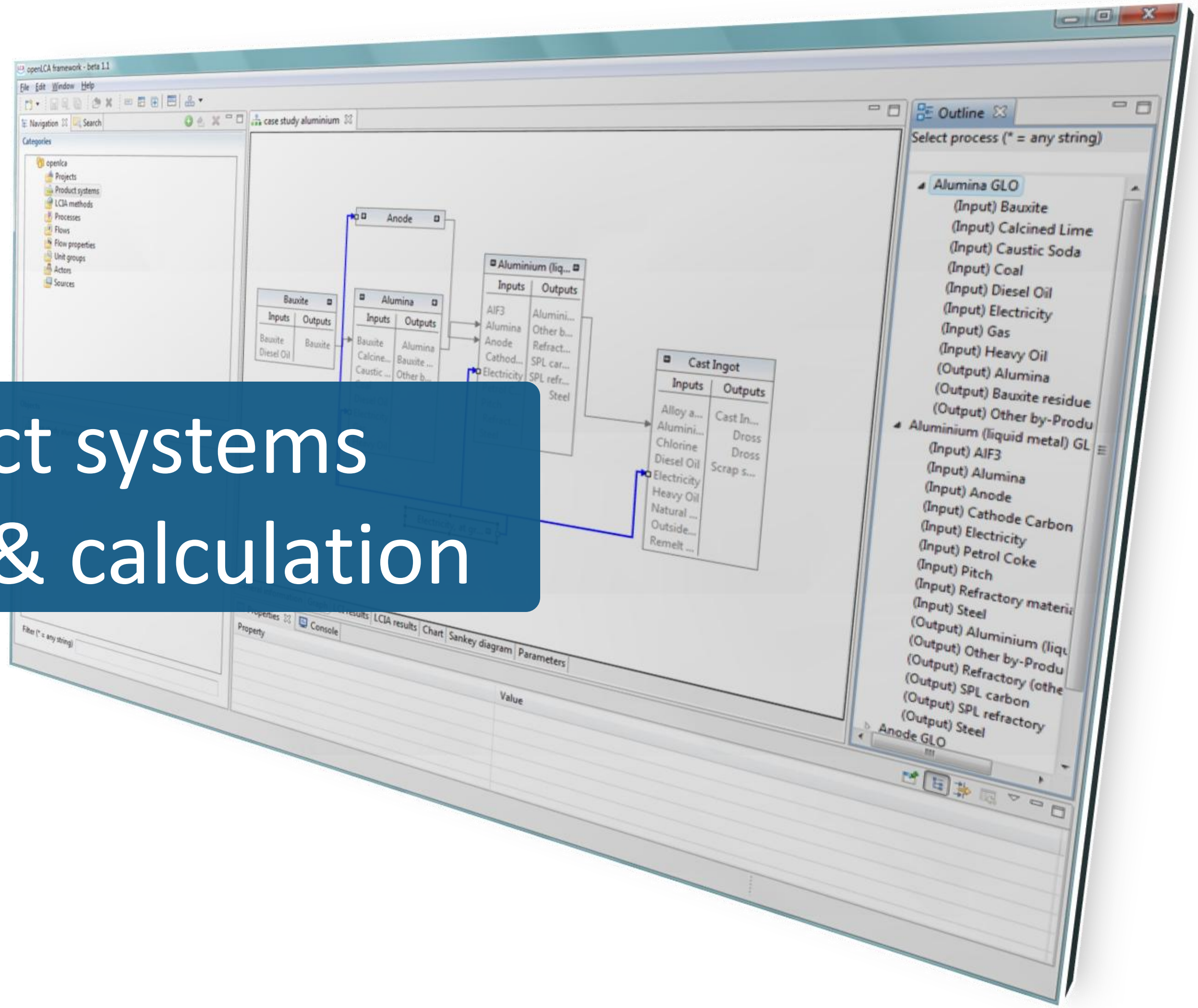
→ Model according to the "value flow direction":

Disposal as a service counter to the direction of material flow

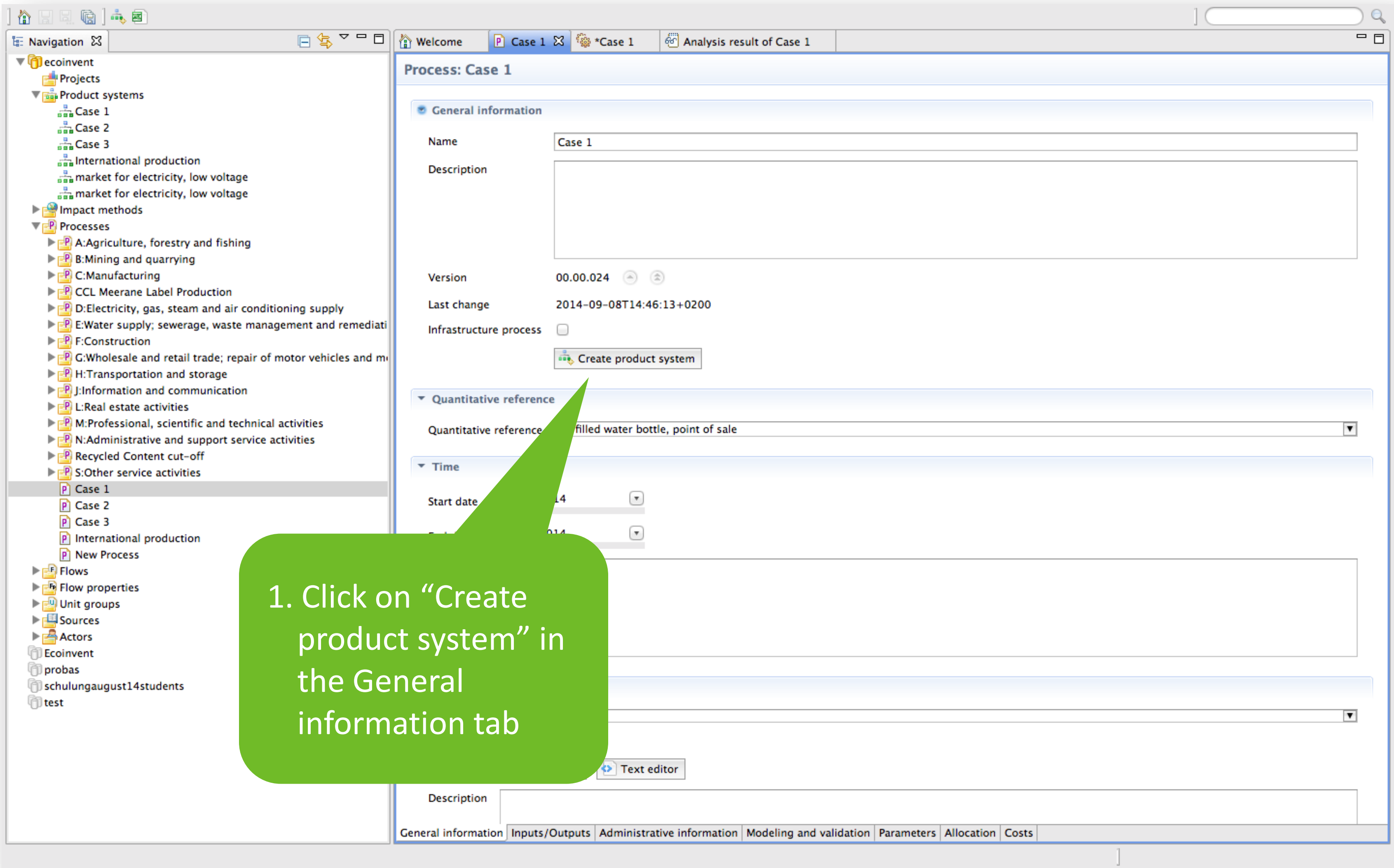
Modeling of waste (II)



Product systems creation & calculation

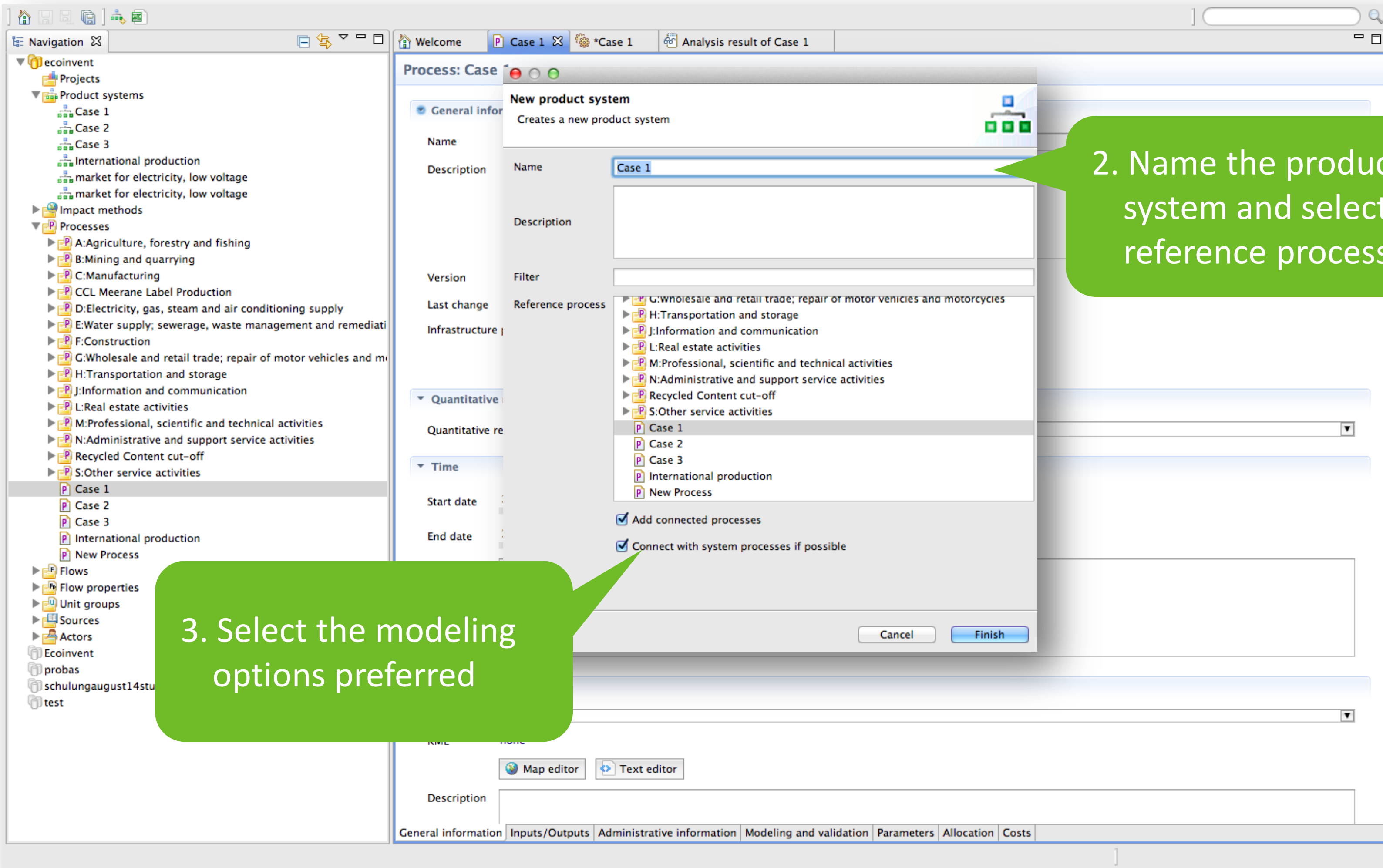


Product system: Creation



GreenDelta

Product system: Creation (II)



2. Name the product system and select a reference process

3. Select the modeling options preferred

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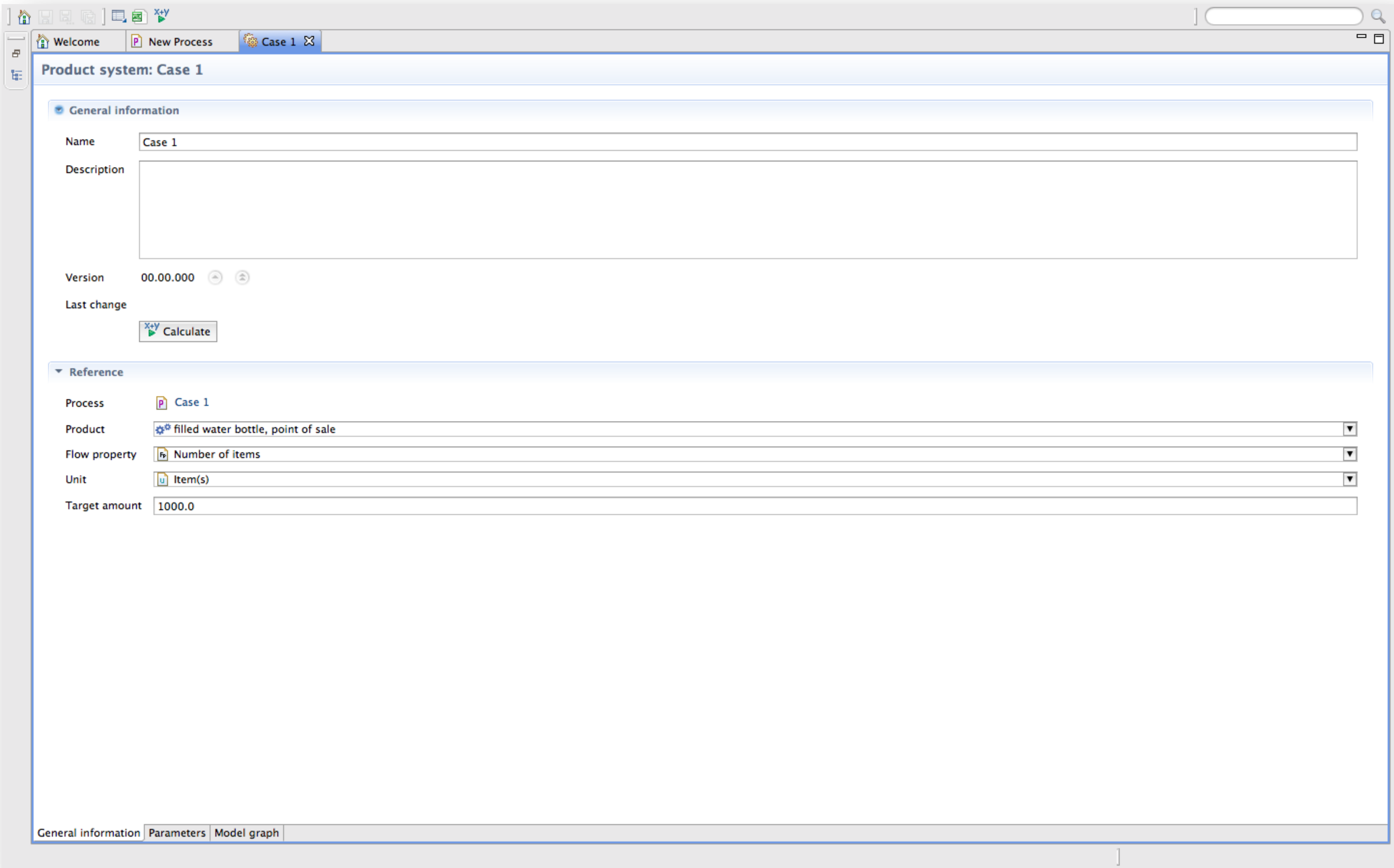
Product system: General information



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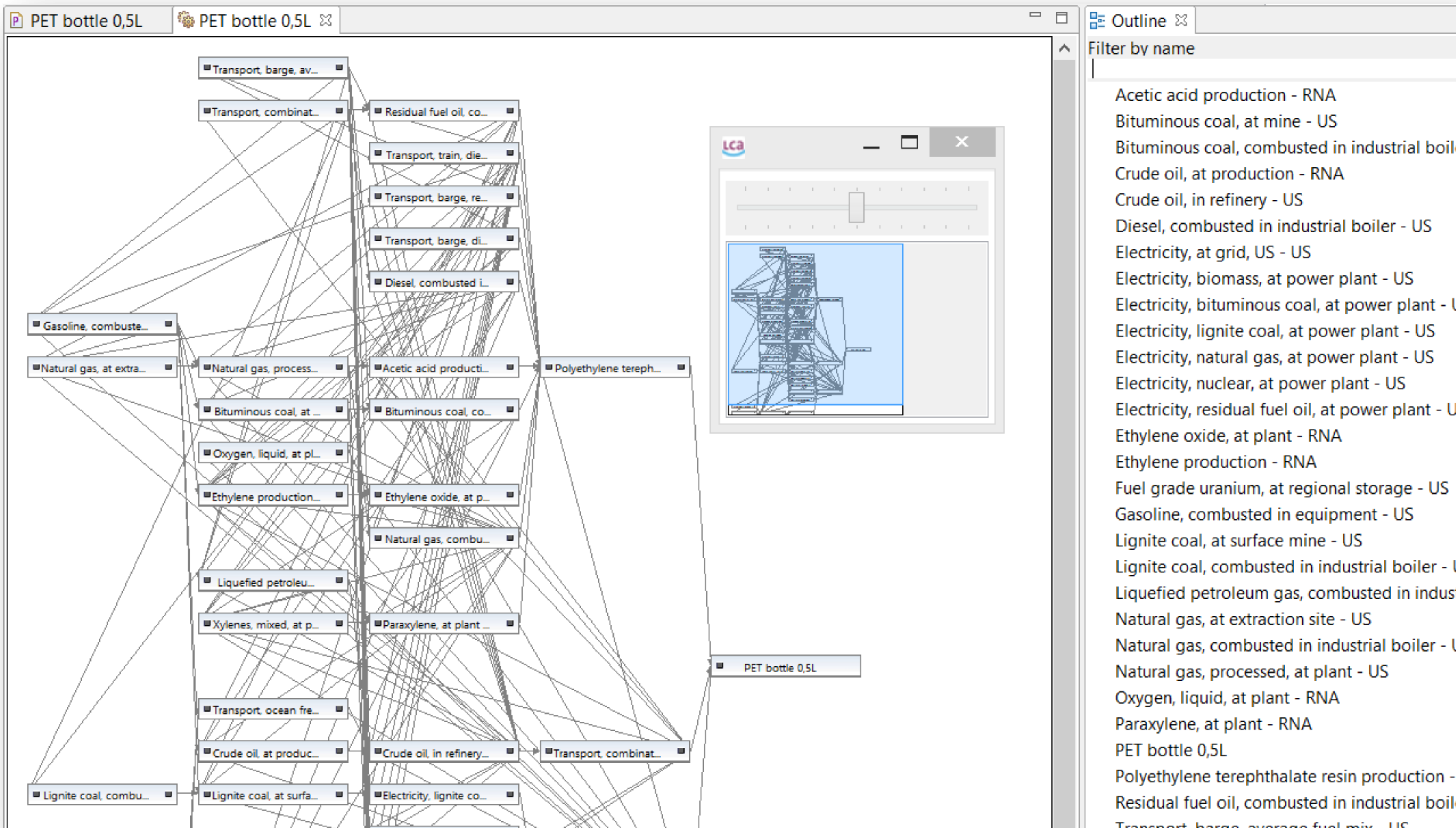
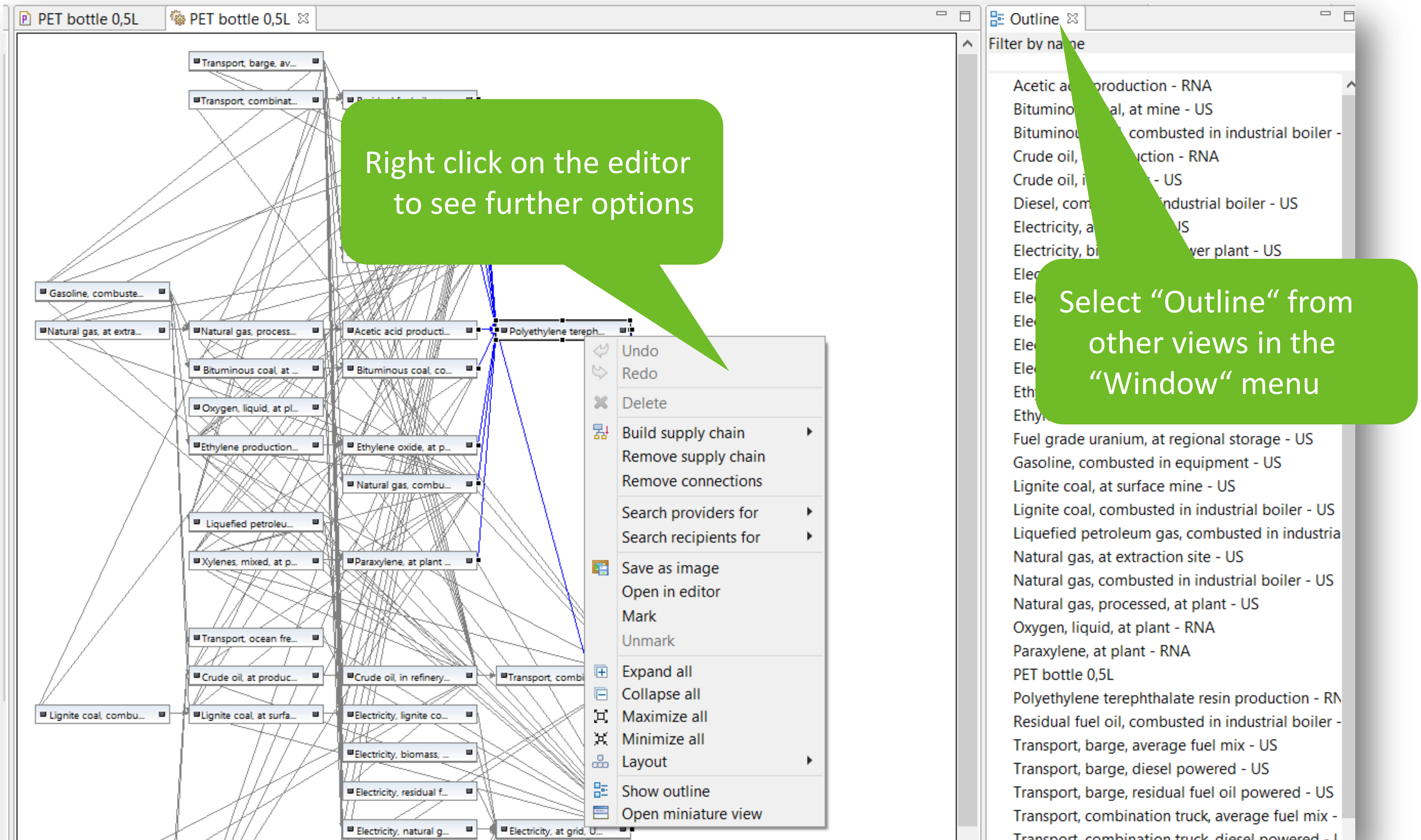
Product system: Model graph



Product system: Model graph (II)



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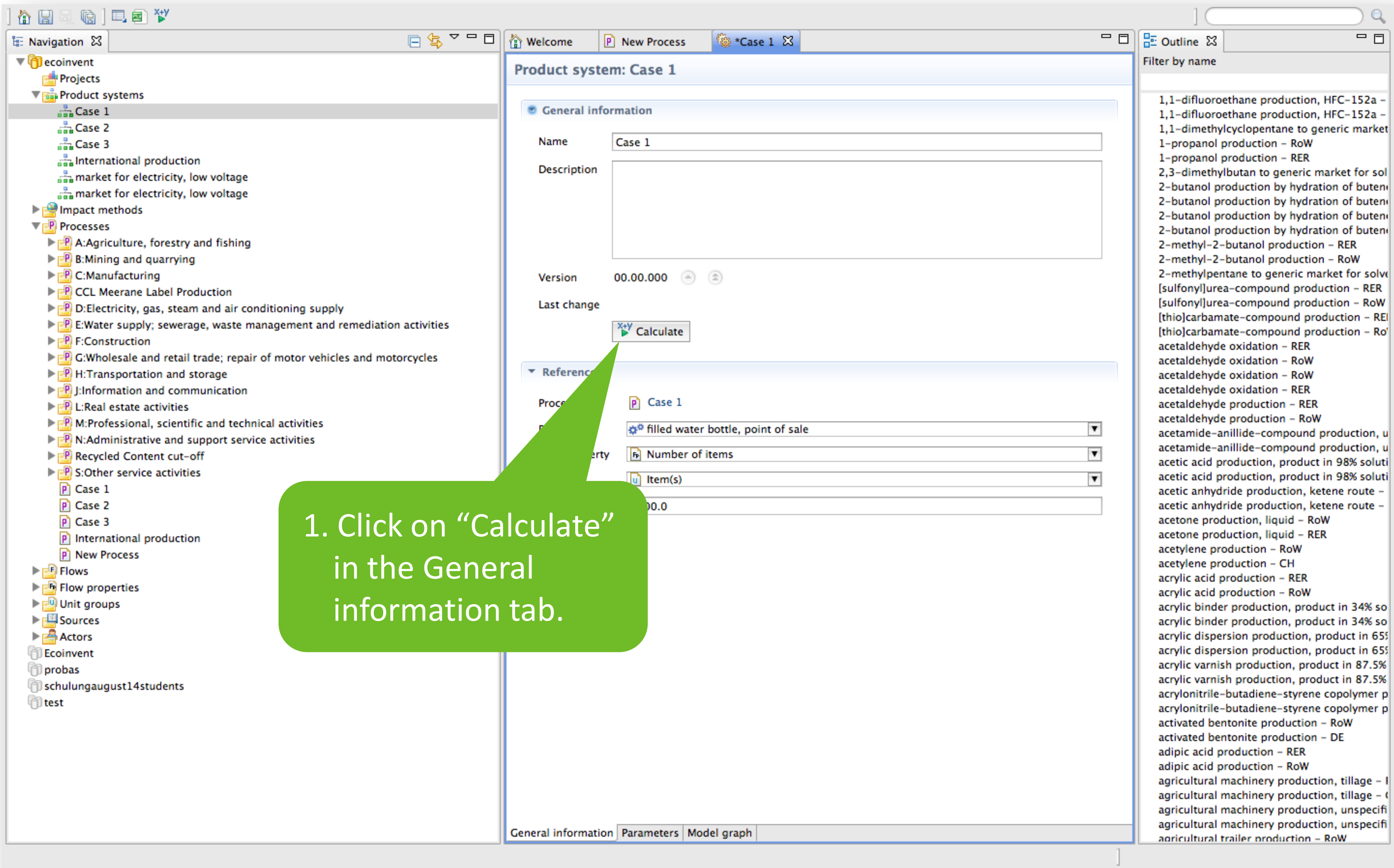
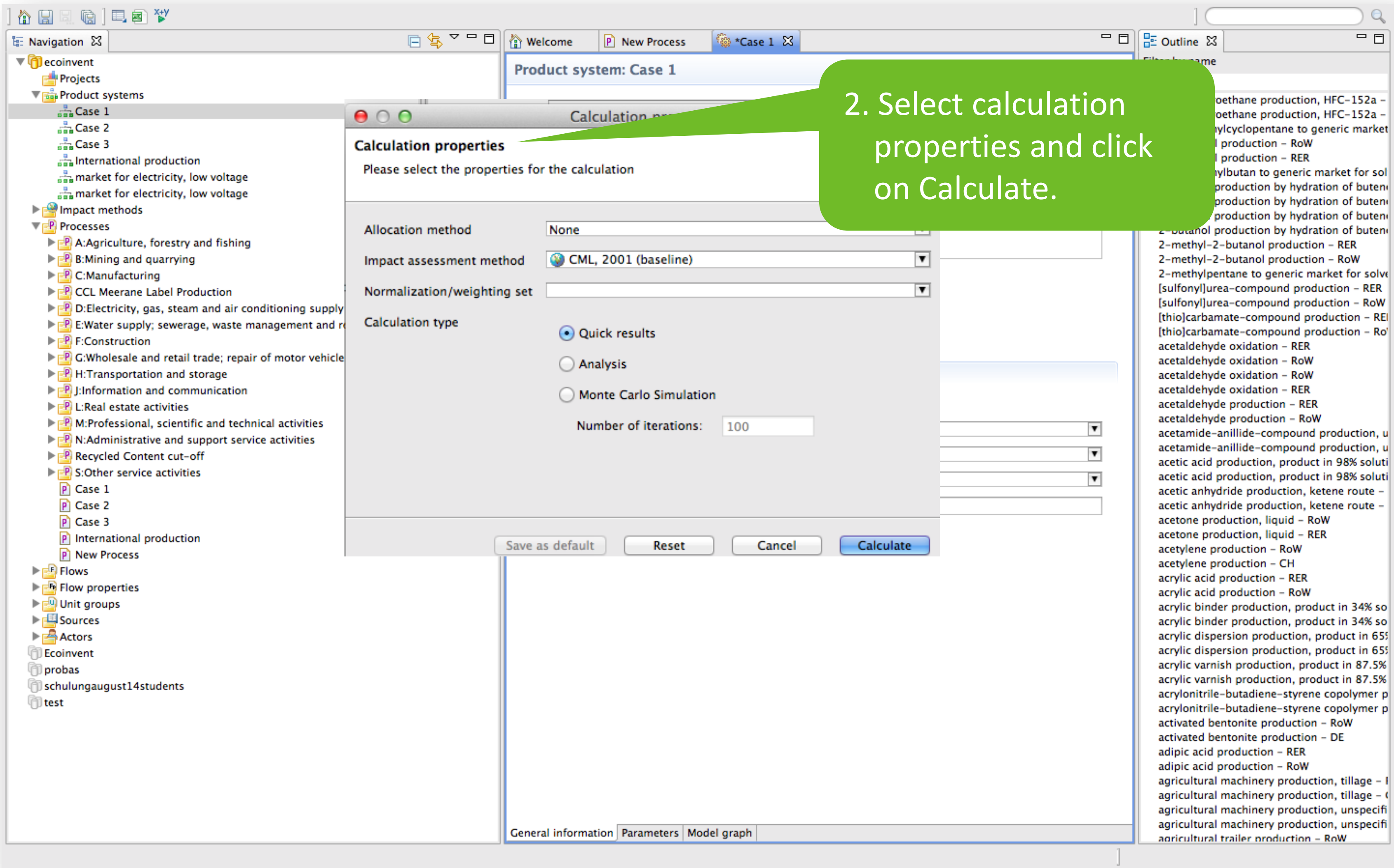
Product system: Calculation

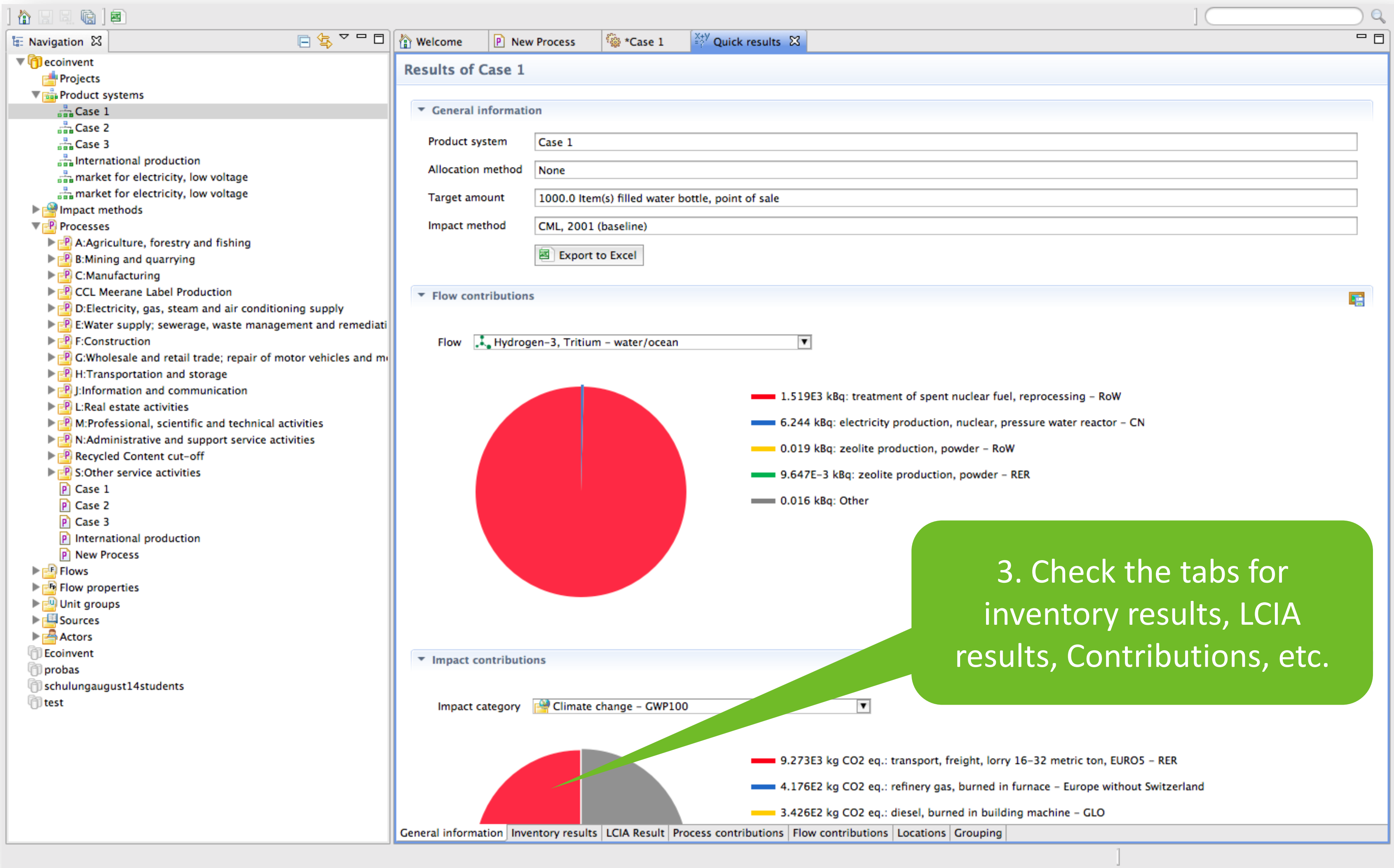


1. Click on “Calculate” in the General information tab.

Product system: Calculation (II)



Product system: Calculation (III)



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

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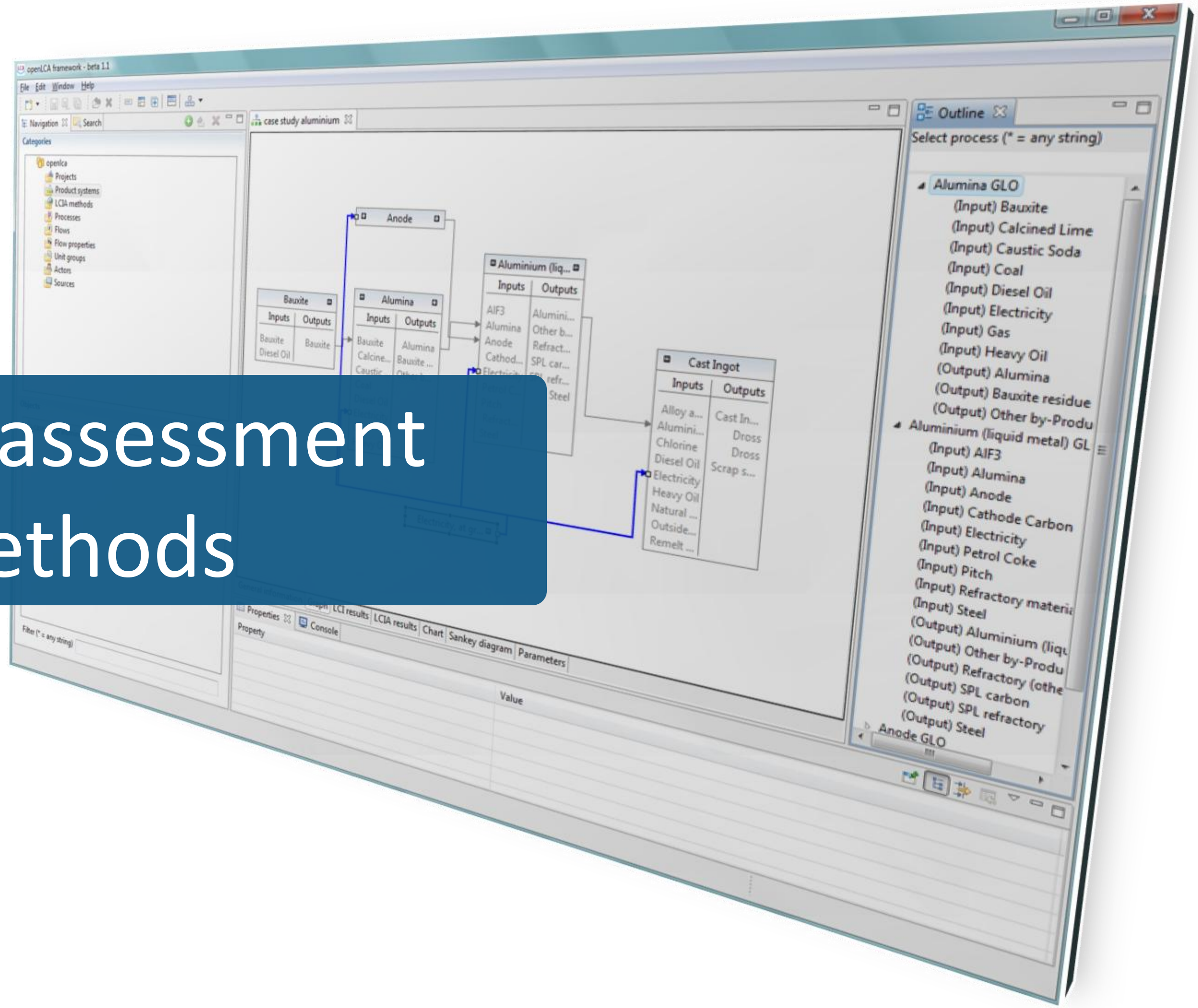
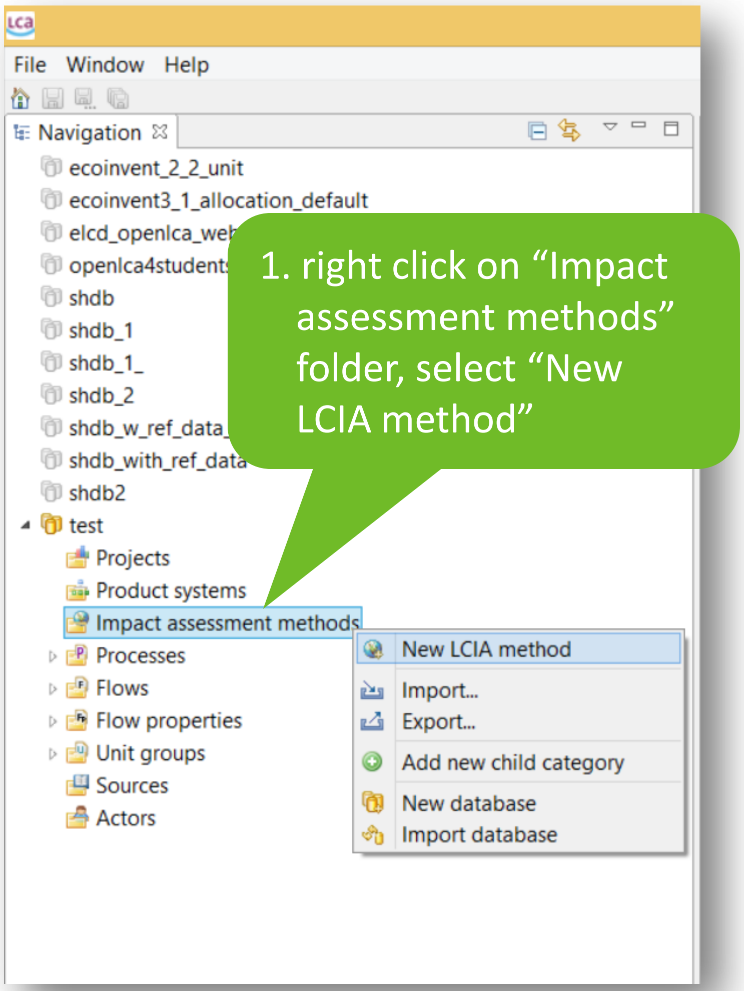
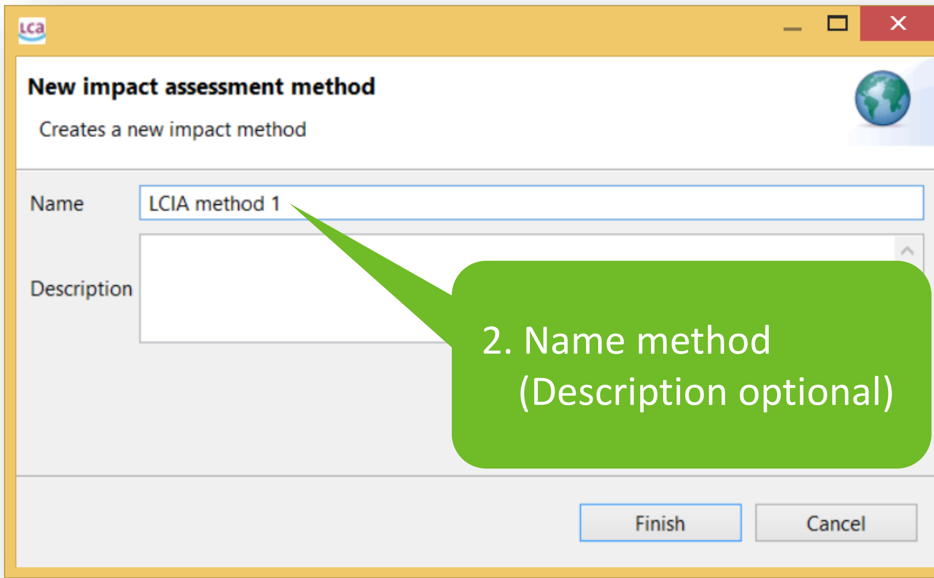
Impact assessment methods



Impact assessment methods: Creation





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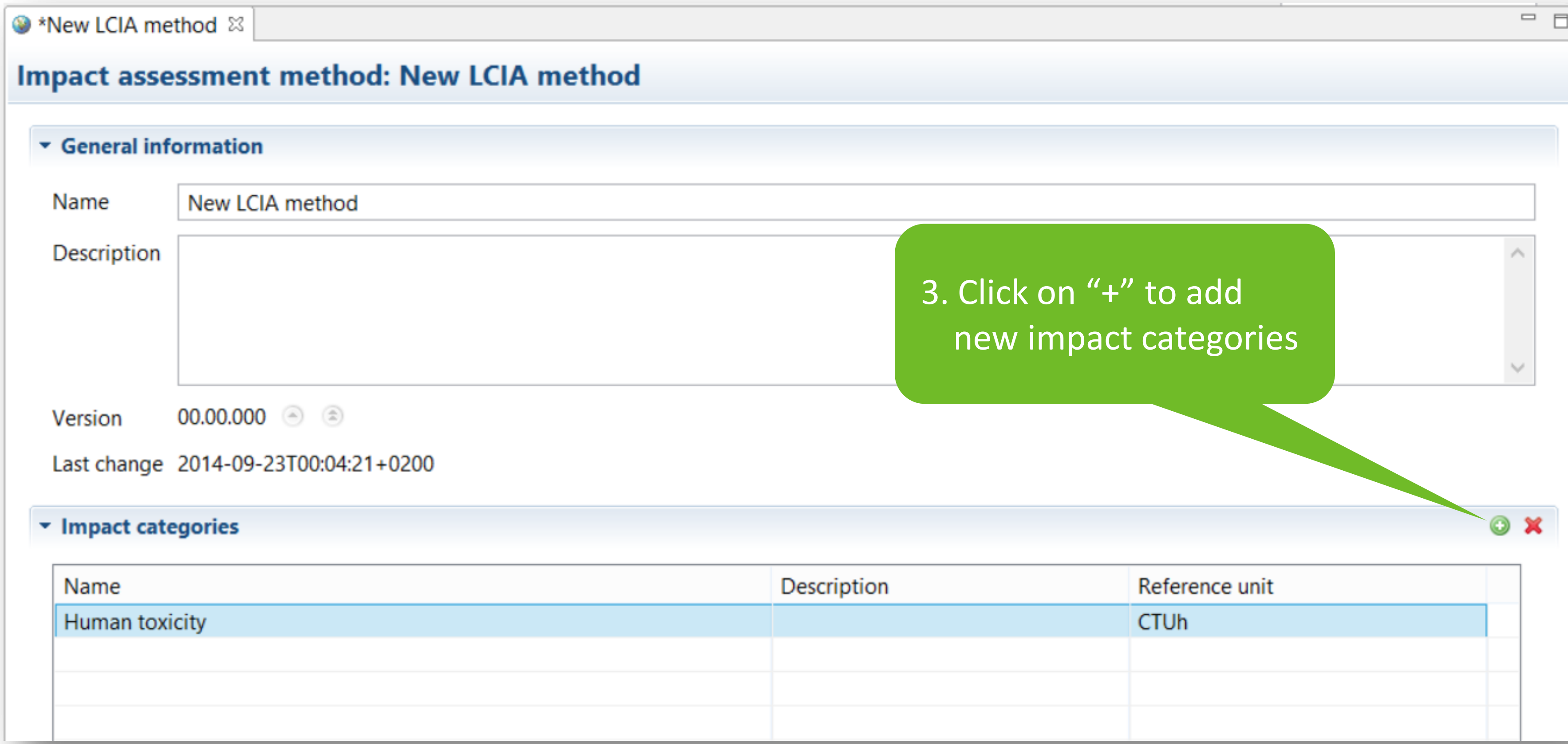
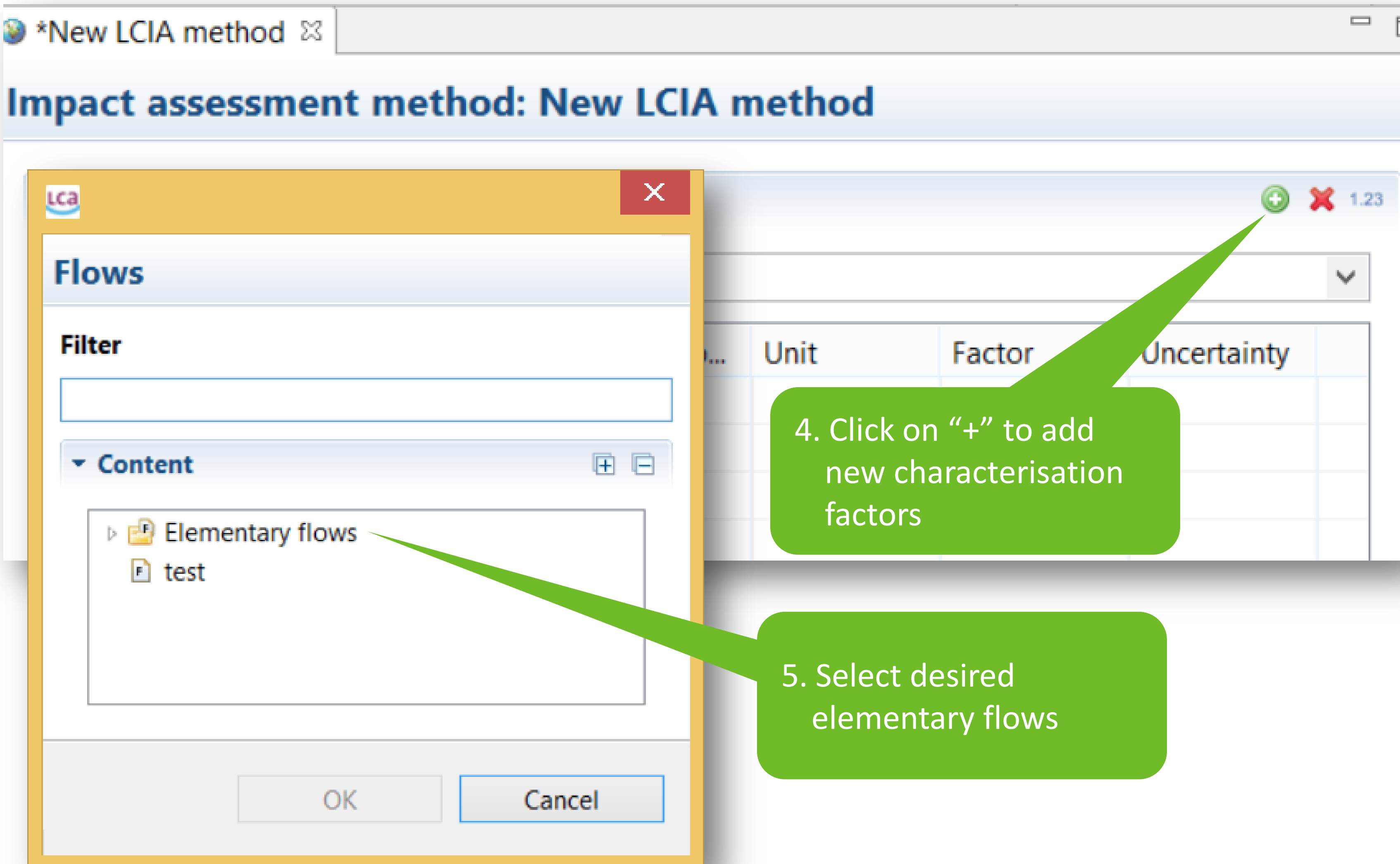
Impact assessment methods: Creation (II)



Impact assessment methods: Creation (III)



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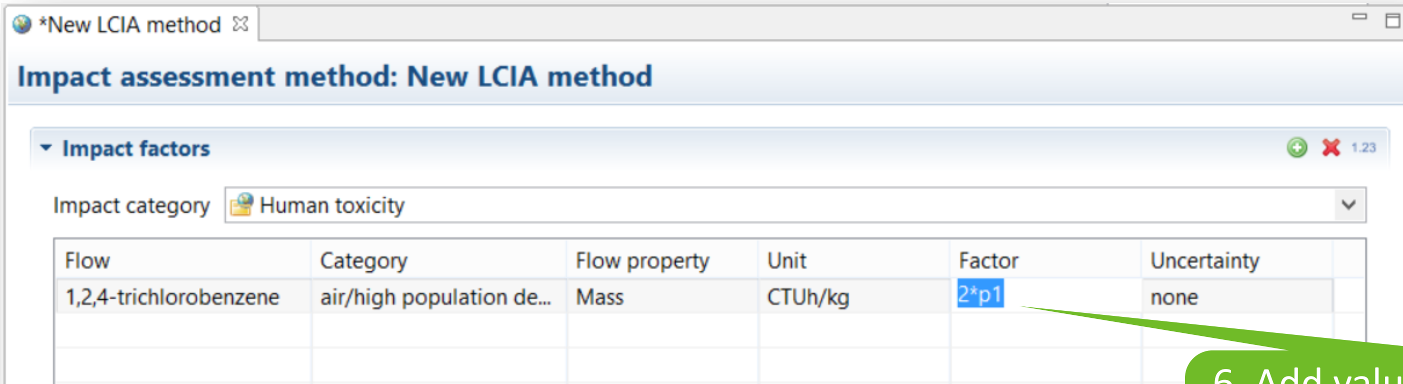
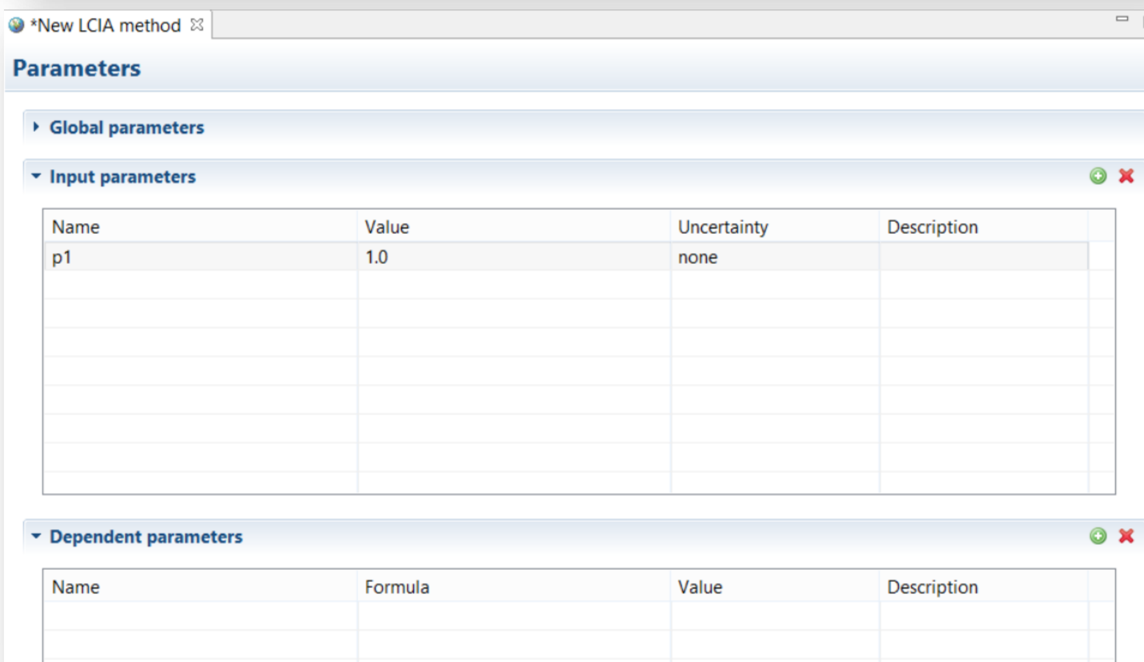
Impact assessment methods: Creation (IV)

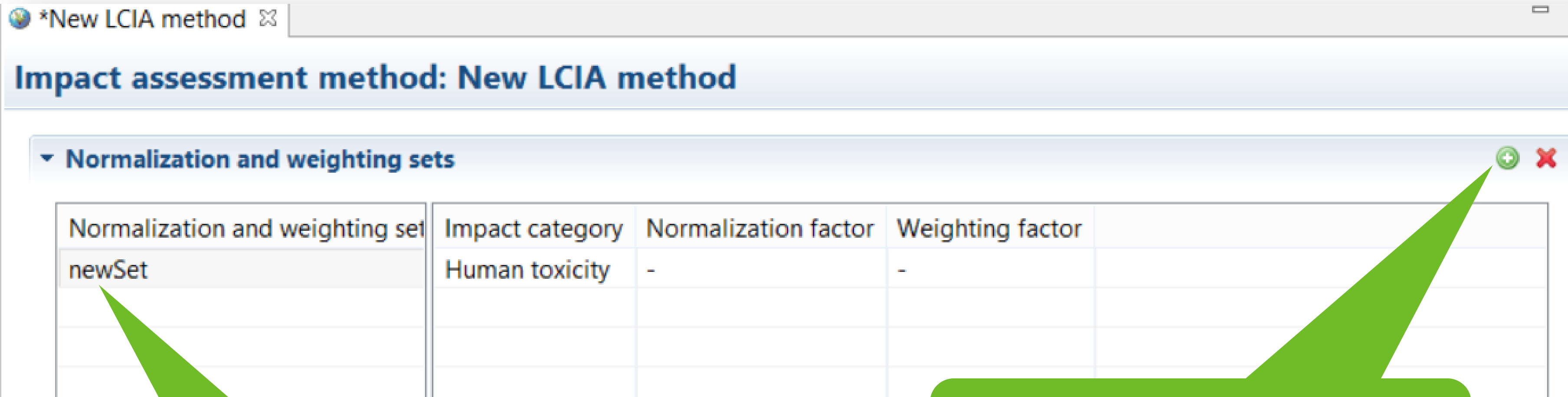


6. Add value for the factor (parameters can be used as in processes!)



GreenDelta

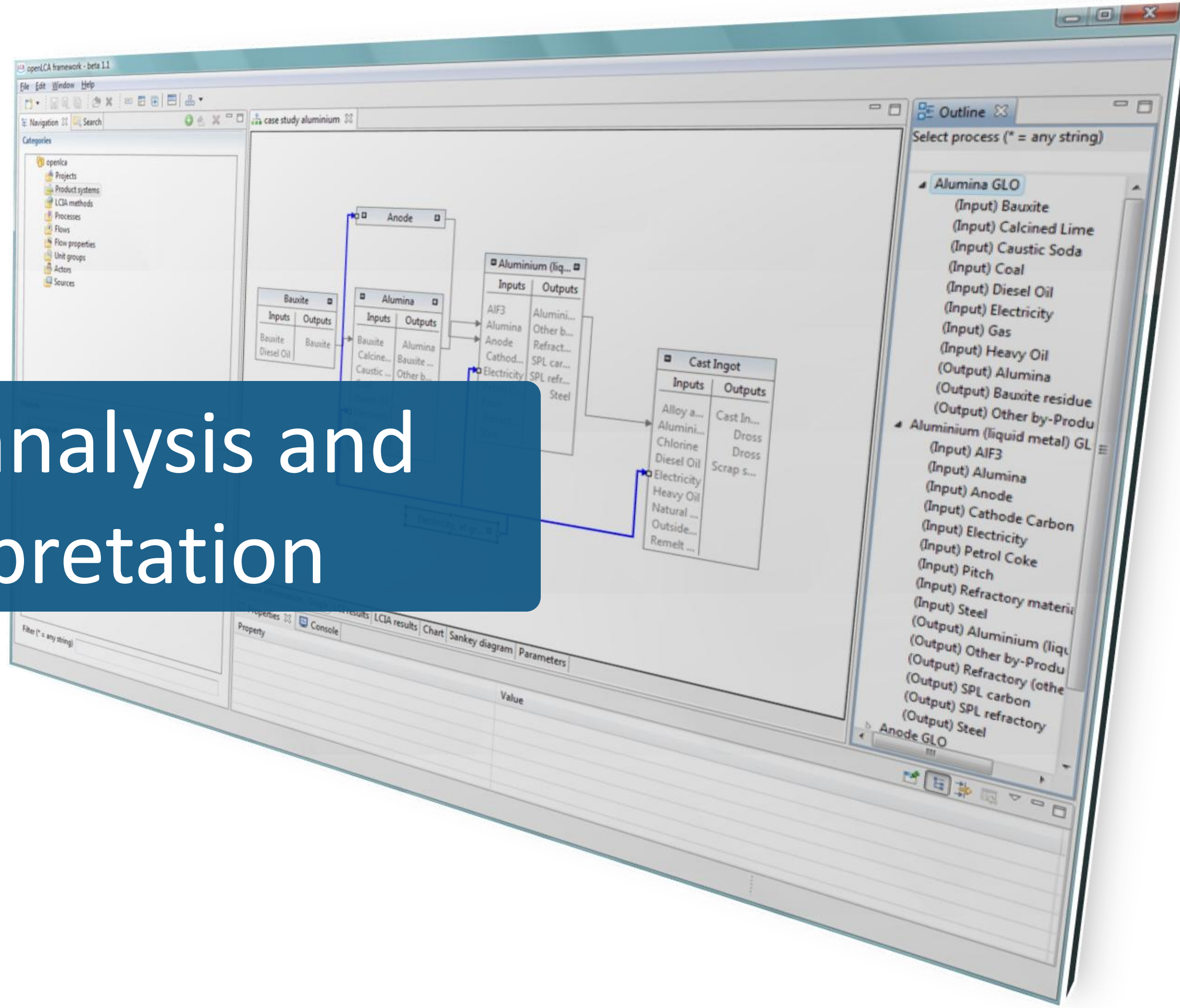
Impact assessment methods: Creation (V)



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

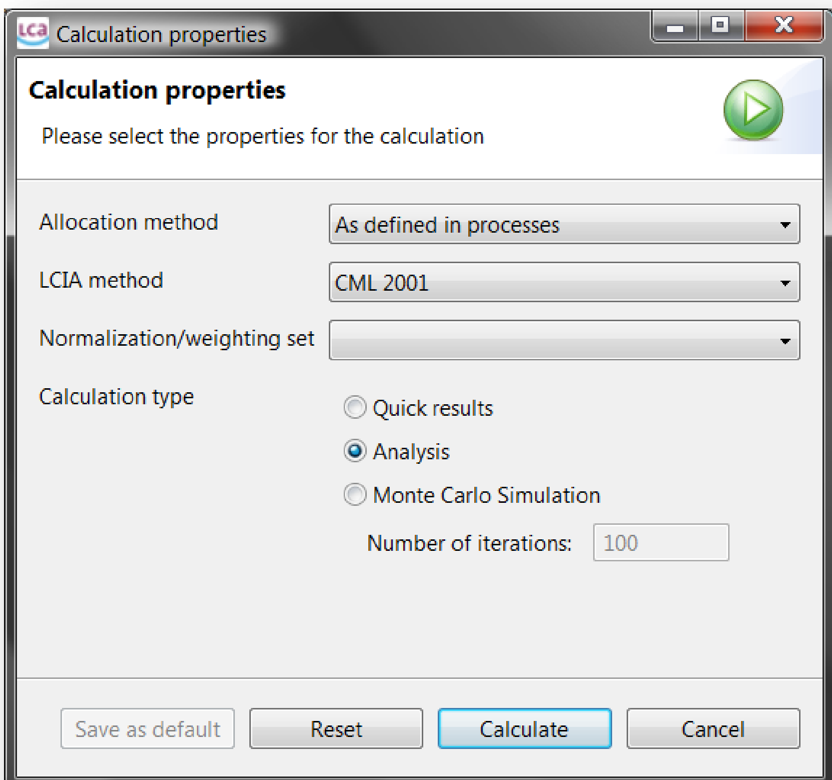
8. Click on the set name to automatically add the impact categories of the method

Result analysis and interpretation

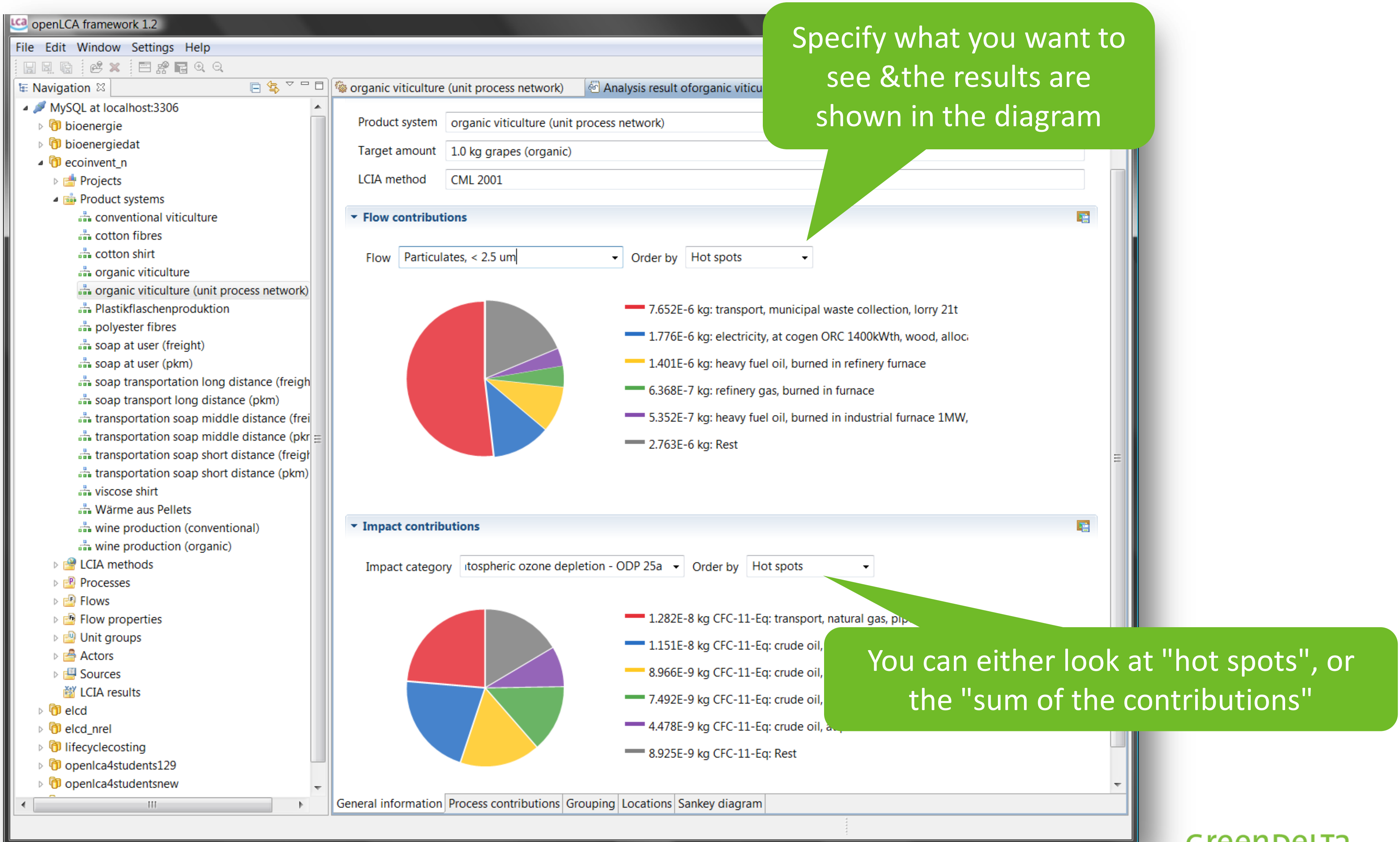


Analysis functions

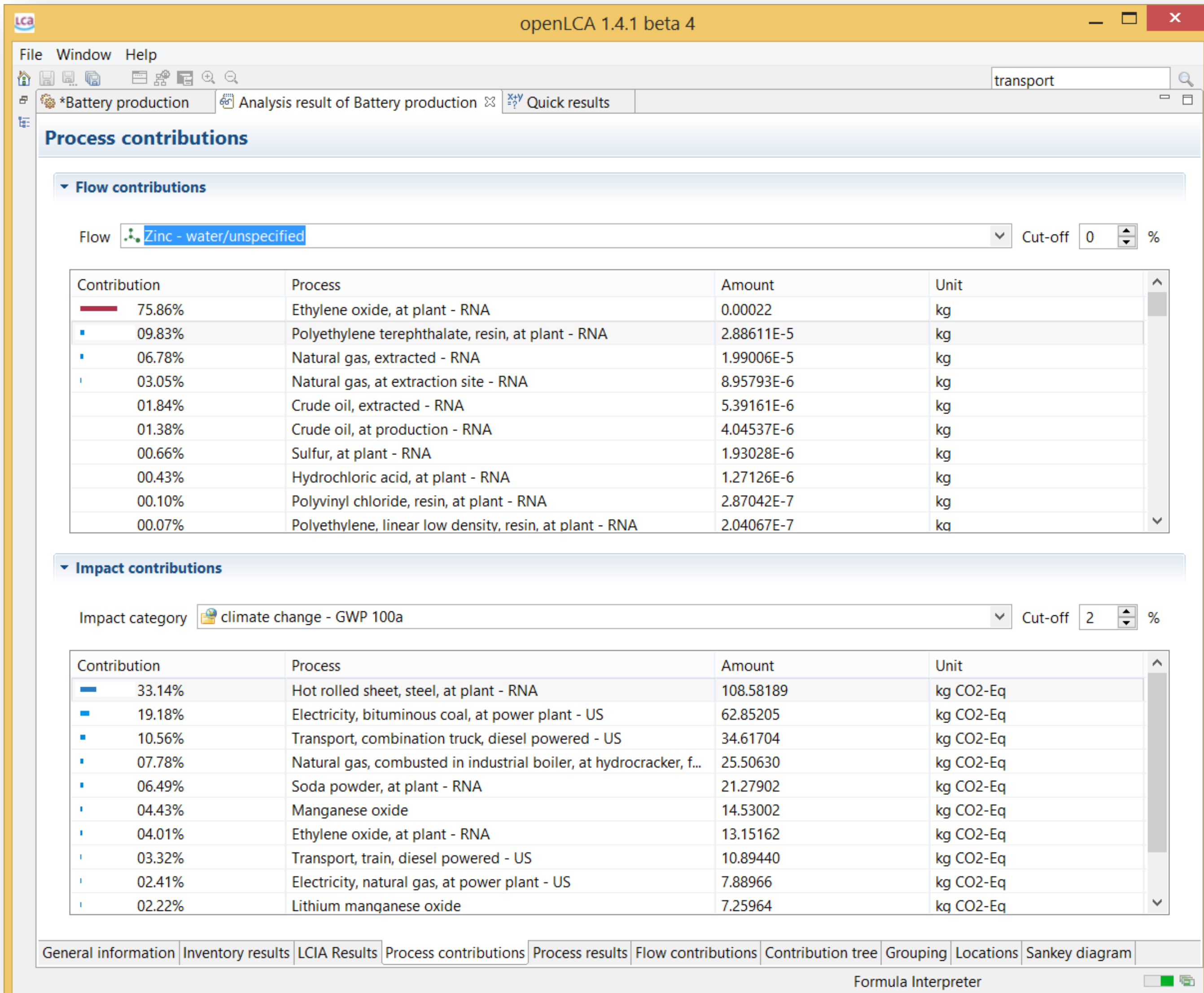
- To run the analysis functions the product system needs to be recalculated
- Click the calculation button in the General Information tab of the Product System, select an LCIA method and check „Analysis“



Analysis: Flow & Impact contributions



Analysis: process contributions



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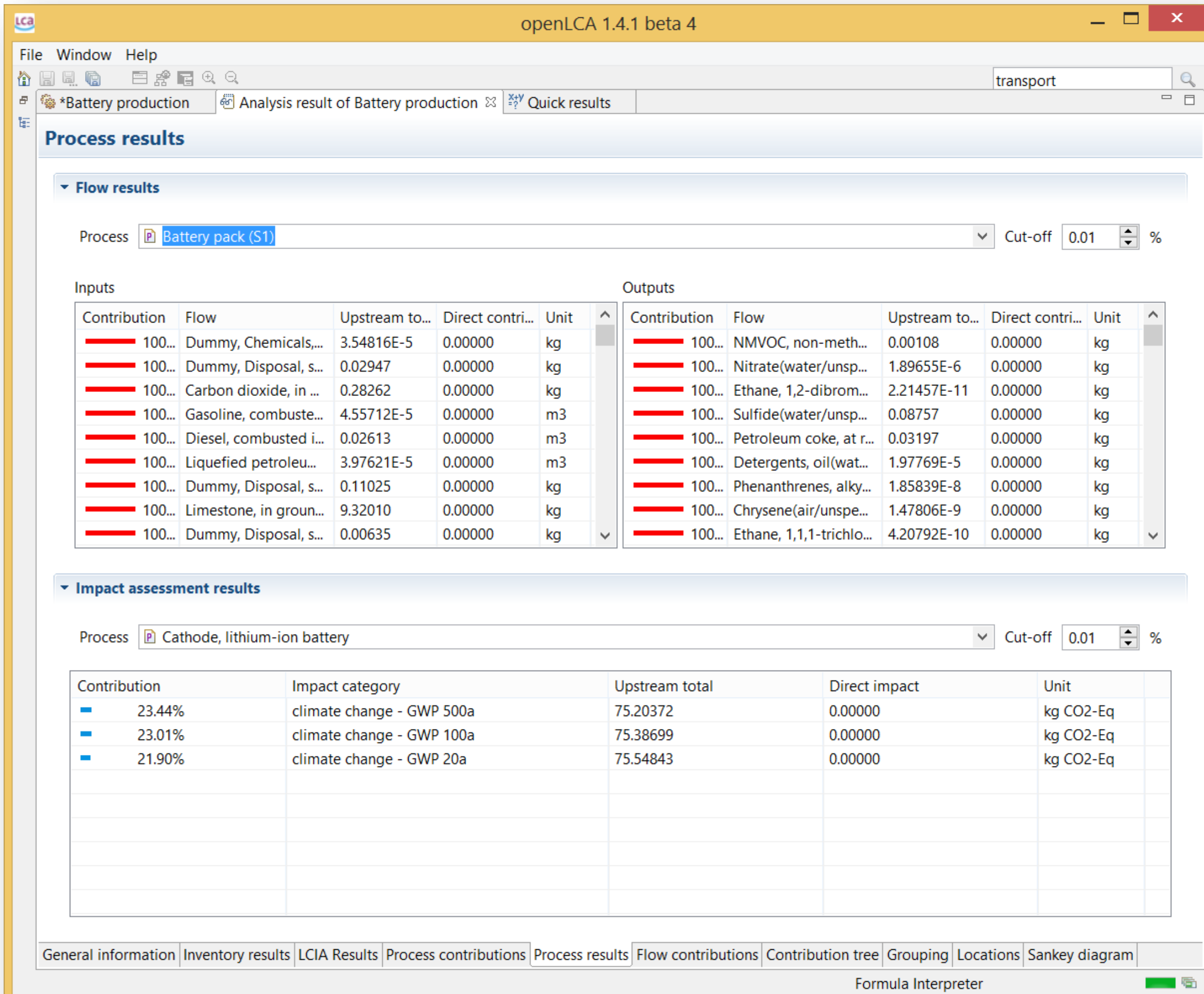
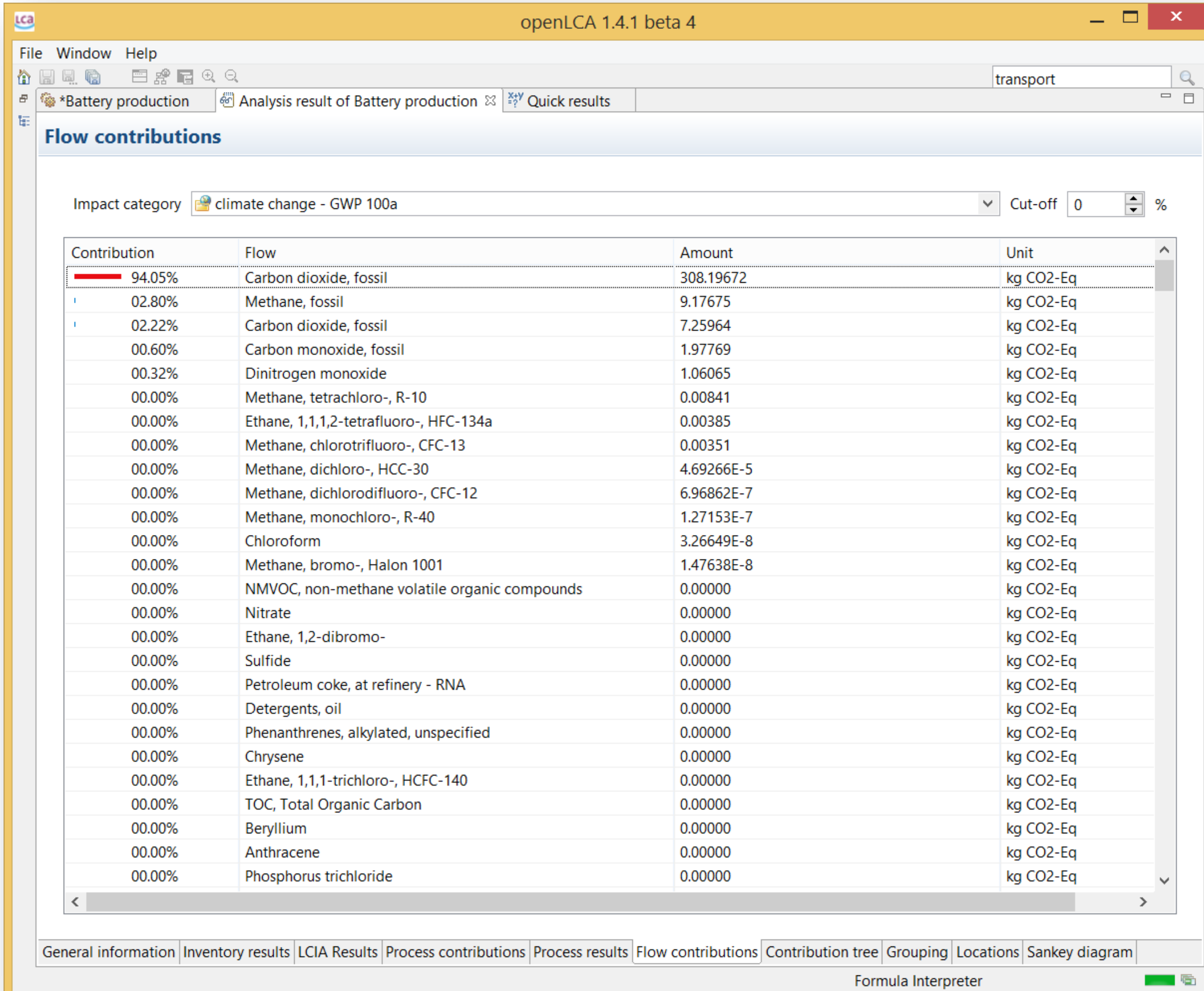
Analysis: process results



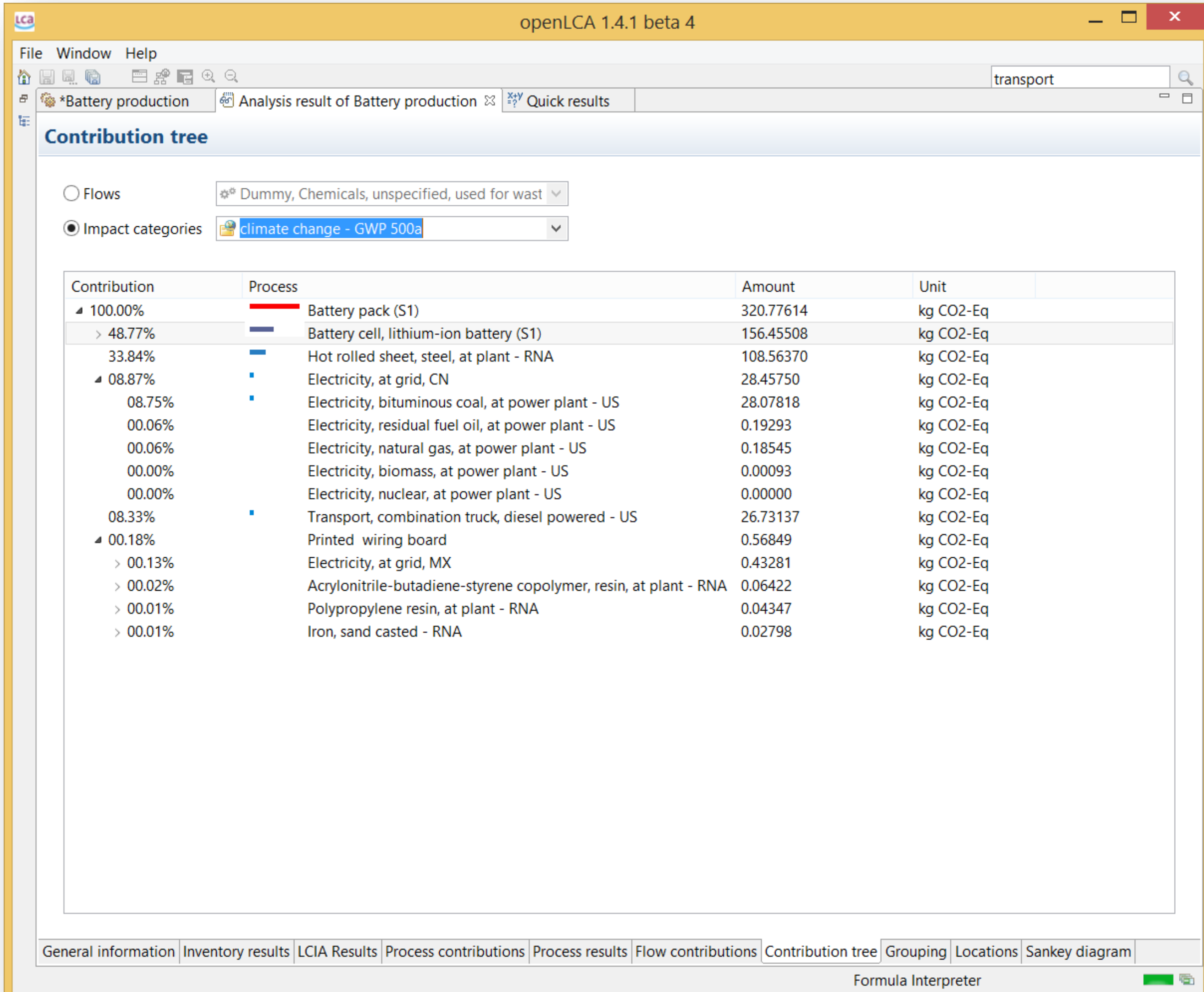
Analysis: flow contributions



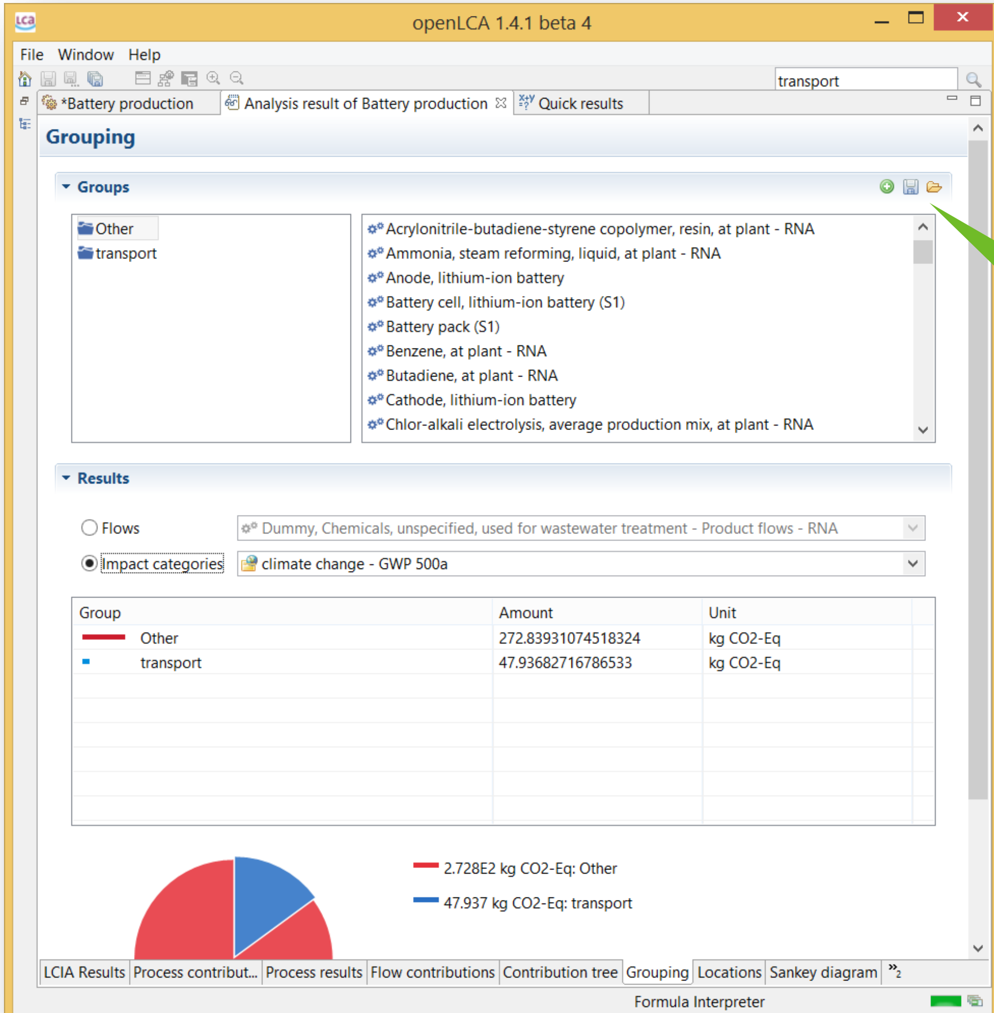
Contribution	Flow	Amount	Unit
94.05%	Carbon dioxide, fossil	308.19672	kg CO2-Eq
02.80%	Methane, fossil	9.17675	kg CO2-Eq
02.22%	Carbon dioxide, fossil	7.25964	kg CO2-Eq
00.60%	Carbon monoxide, fossil	1.97769	kg CO2-Eq
00.32%	Dinitrogen monoxide	1.06065	kg CO2-Eq
00.00%	Methane, tetrachloro-, R-10	0.00841	kg CO2-Eq
00.00%	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	0.00385	kg CO2-Eq
00.00%	Methane, chlorotrifluoro-, CFC-13	0.00351	kg CO2-Eq
00.00%	Methane, dichloro-, HCC-30	4.69266E-5	kg CO2-Eq
00.00%	Methane, dichlorodifluoro-, CFC-12	6.96862E-7	kg CO2-Eq
00.00%	Methane, monochloro-, R-40	1.27153E-7	kg CO2-Eq
00.00%	Chloroform	3.26649E-8	kg CO2-Eq
00.00%	Methane, bromo-, Halon 1001	1.47638E-8	kg CO2-Eq
00.00%	NMVOC, non-methane volatile organic compounds	0.00000	kg CO2-Eq
00.00%	Nitrate	0.00000	kg CO2-Eq
00.00%	Ethane, 1,2-dibromo-	0.00000	kg CO2-Eq
00.00%	Sulfide	0.00000	kg CO2-Eq
00.00%	Petroleum coke, at refinery - RNA	0.00000	kg CO2-Eq
00.00%	Detergents, oil	0.00000	kg CO2-Eq
00.00%	Phenanthrenes, alkylated, unspecified	0.00000	kg CO2-Eq
00.00%	Chrysene	0.00000	kg CO2-Eq
00.00%	Ethane, 1,1,1-trichloro-, HCFC-140	0.00000	kg CO2-Eq
00.00%	TOC, Total Organic Carbon	0.00000	kg CO2-Eq
00.00%	Beryllium	0.00000	kg CO2-Eq
00.00%	Anthracene	0.00000	kg CO2-Eq
00.00%	Phosphorus trichloride	0.00000	kg CO2-Eq

GreenDelta

Analysis: contribution tree

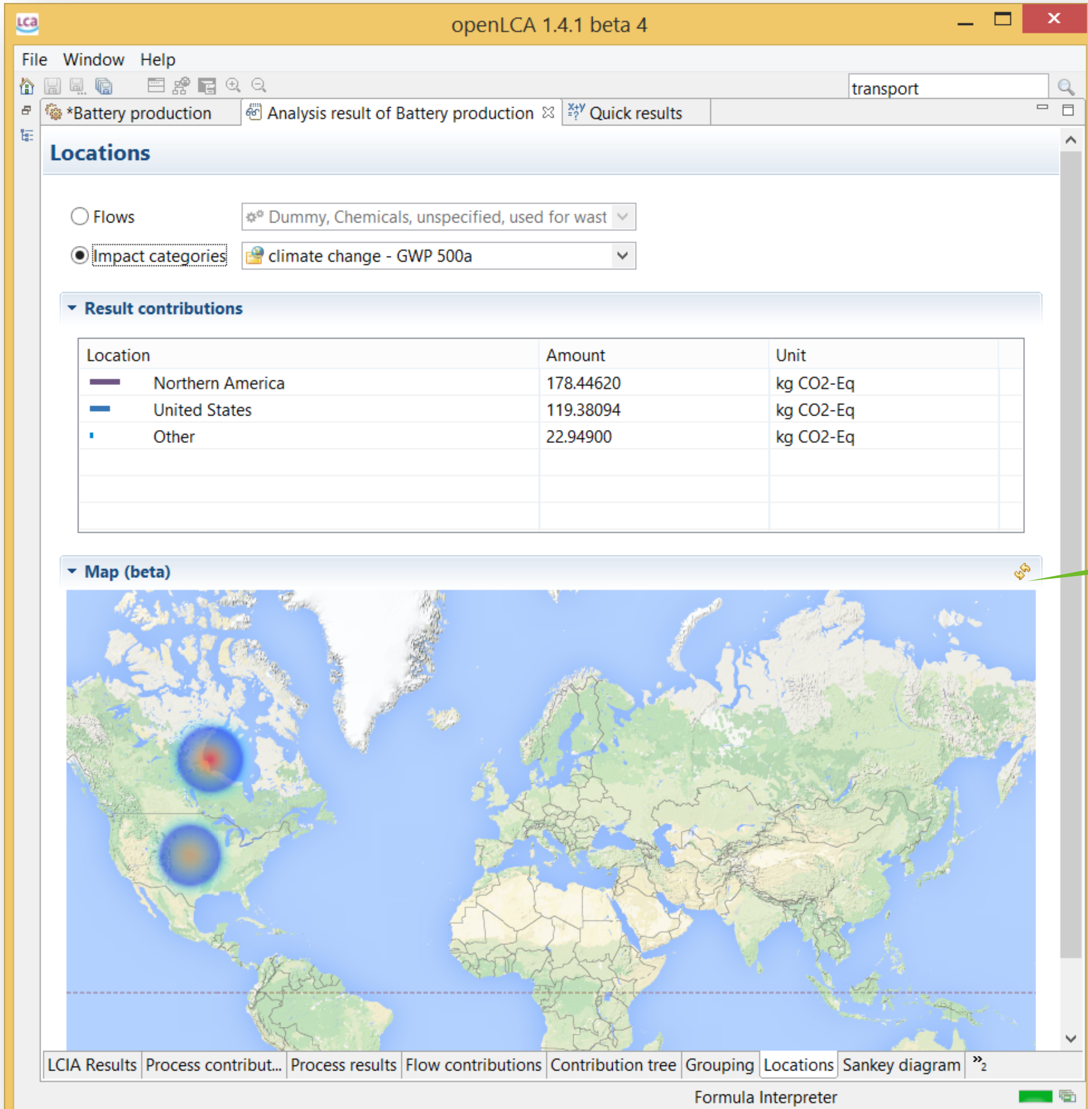


Analysis: grouping



Add new groups and move (right click on process name) processes to them

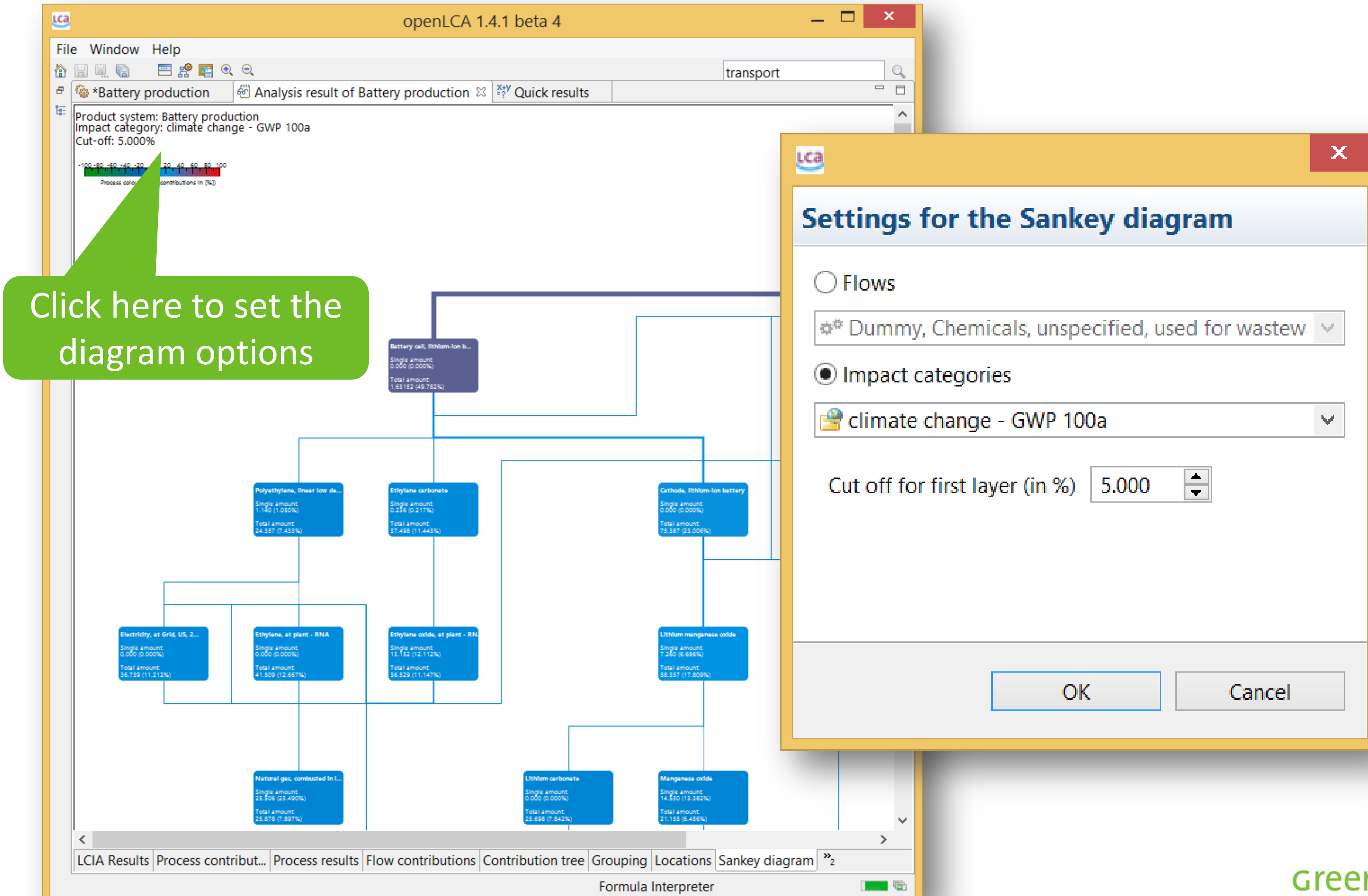
Analysis: locations



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

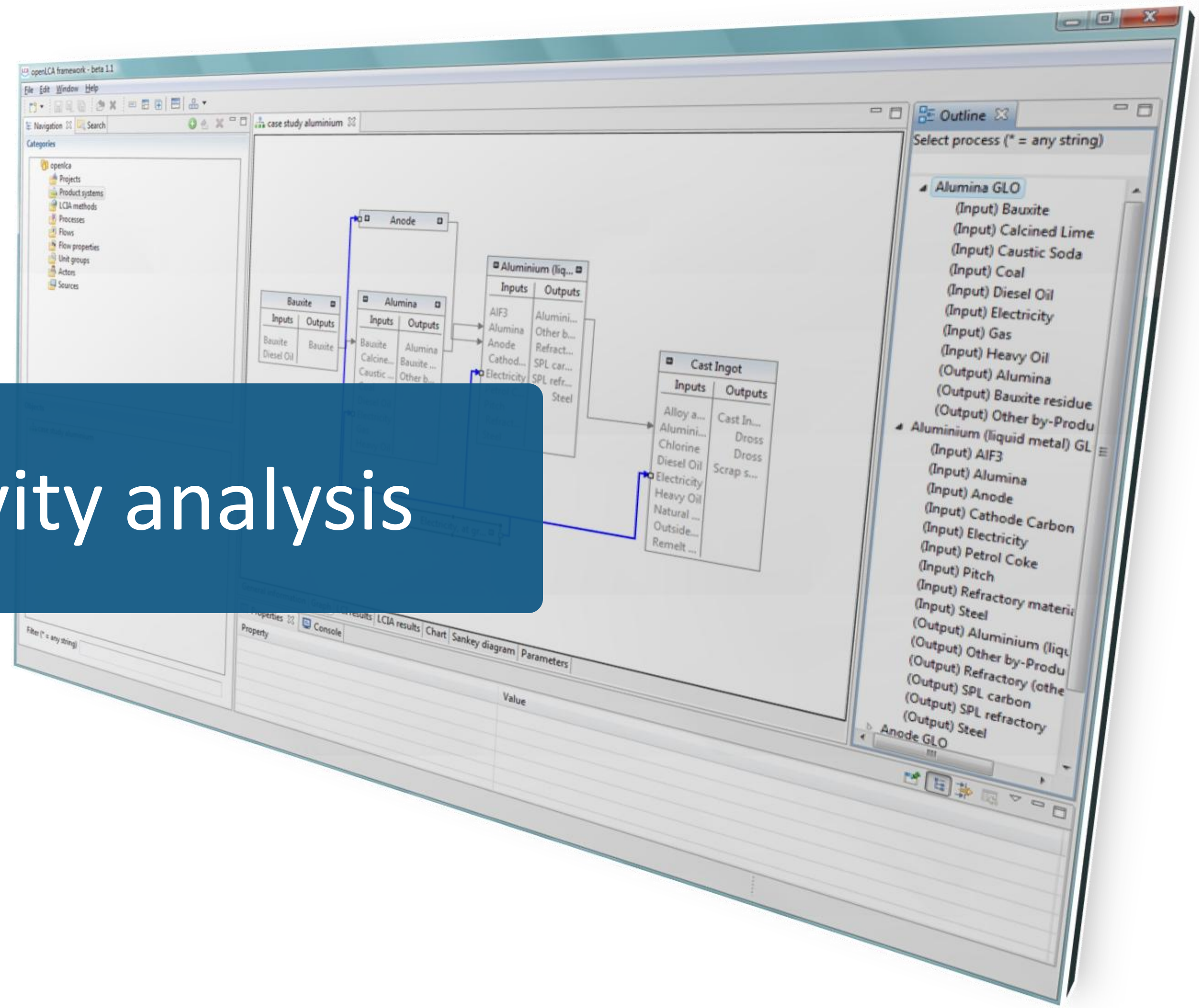
GreenDelta

Analysis: Sankey diagram



GreenDelta

Sensitivity analysis



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?
  - ...

Modeling with parameters

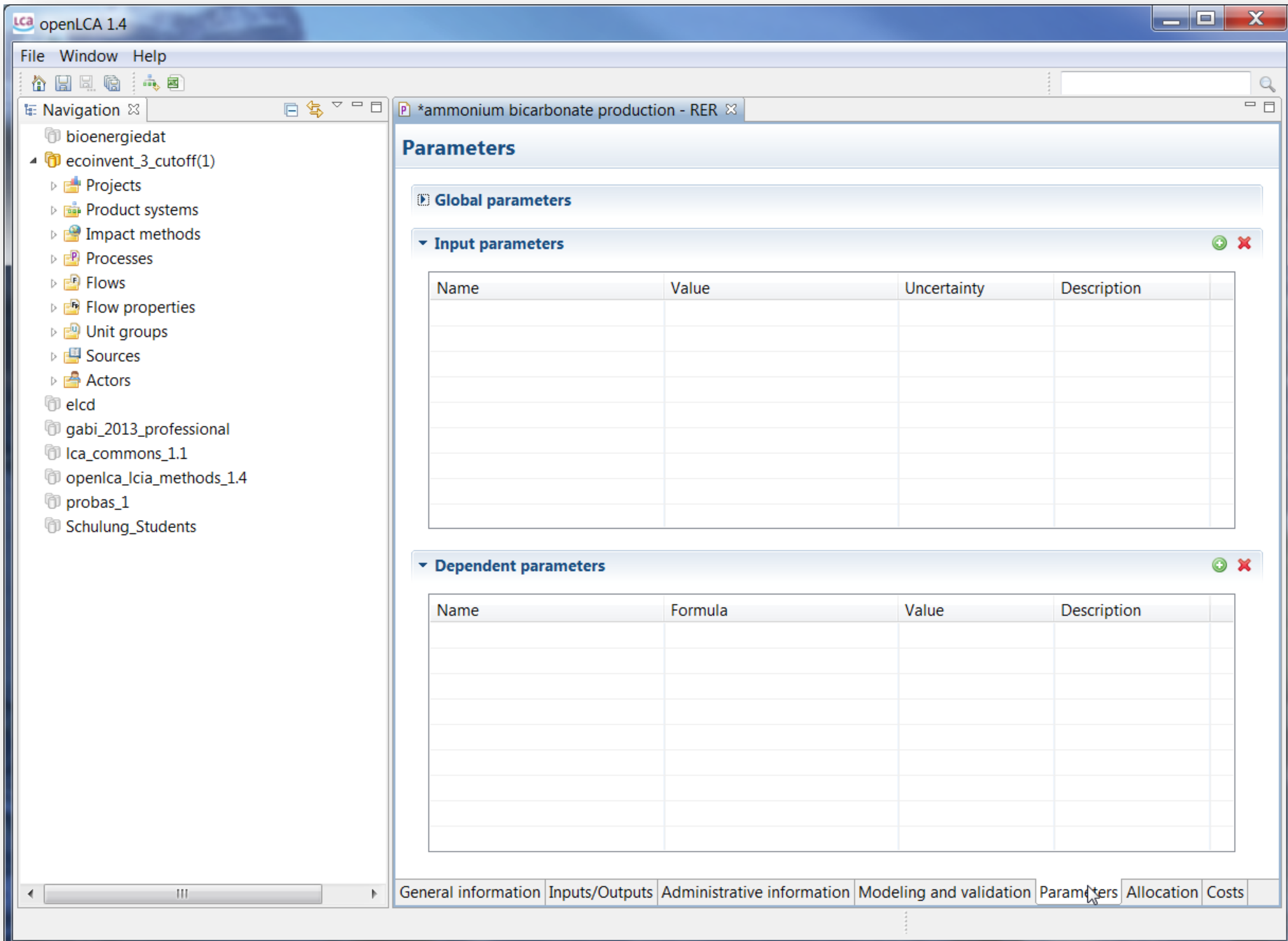
- Useful for sensitivity analyses → What impact does one aspect have when I change its value?
- Useful for preliminary data: data can be changed easily at the end of your study
- Create different versions of your life cycle by changing the input values
- Reduces the likelihood of calculation errors

Modeling with parameters

- 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

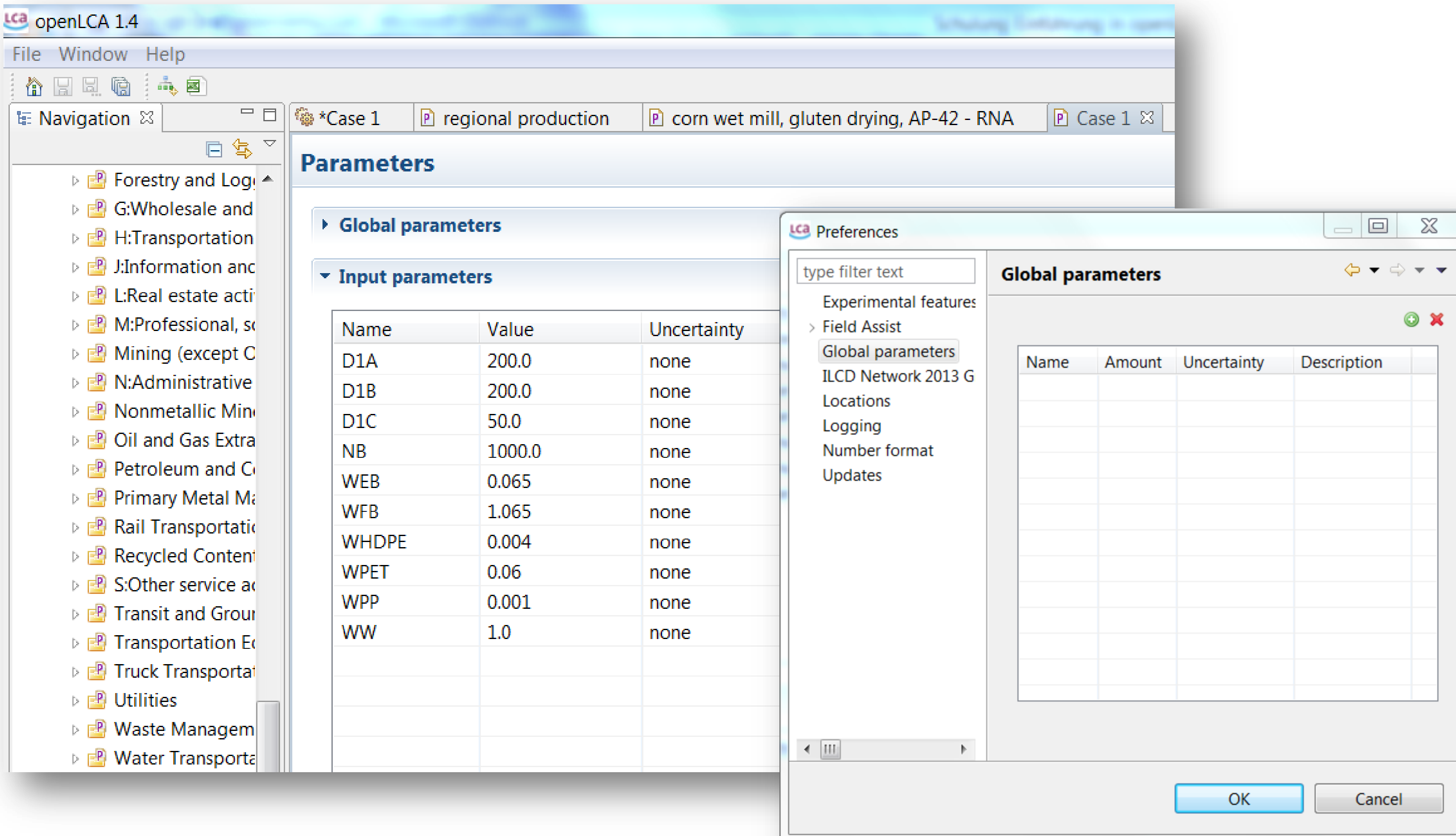
GreenDelta

Process: Parameters



GreenDelta

Process: Parameters (II)



Process: Parameters (III)

Process: Plane, technology mix, cargo, 68 t payload

Inputs

Flow	Category	Flow proper...	Unit	Amount	Uncertainty	Default pro...	Pedigree un...
kerosene	Energy carriers and...	Mass	kg	Spez_Verbr	none		
cargo	Transport services/...	Mass	kg	1.0	none		

Click here to change the formula view

Outputs

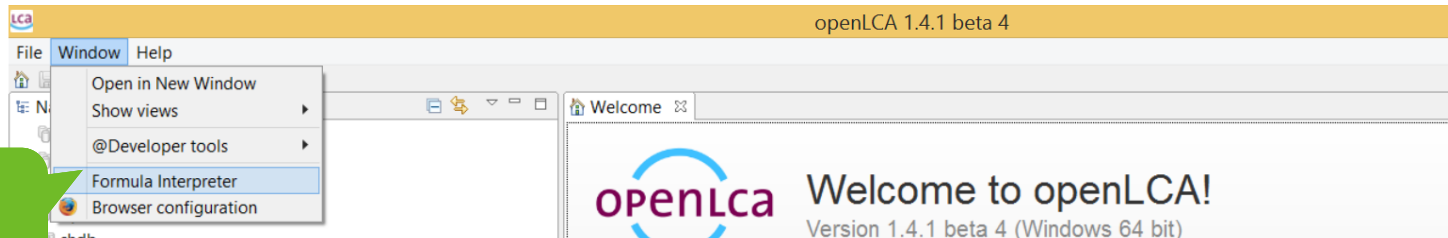
Flow	Category	Flow proper...	Unit	Amount	Uncertainty	Avoided pr...	F
cargo	Transport services/...	Mass	kg	1.0	none		
Sulfur dioxide	air/unspecified	Mass	kg	(5.0E-5 * Spez_Verbr) * 1.0	none		
Nitrogen dioxide	air/unspecified	Mass	kg	(0.016321 * Spez_Verbr) * 1.0	none		

Parameter rules

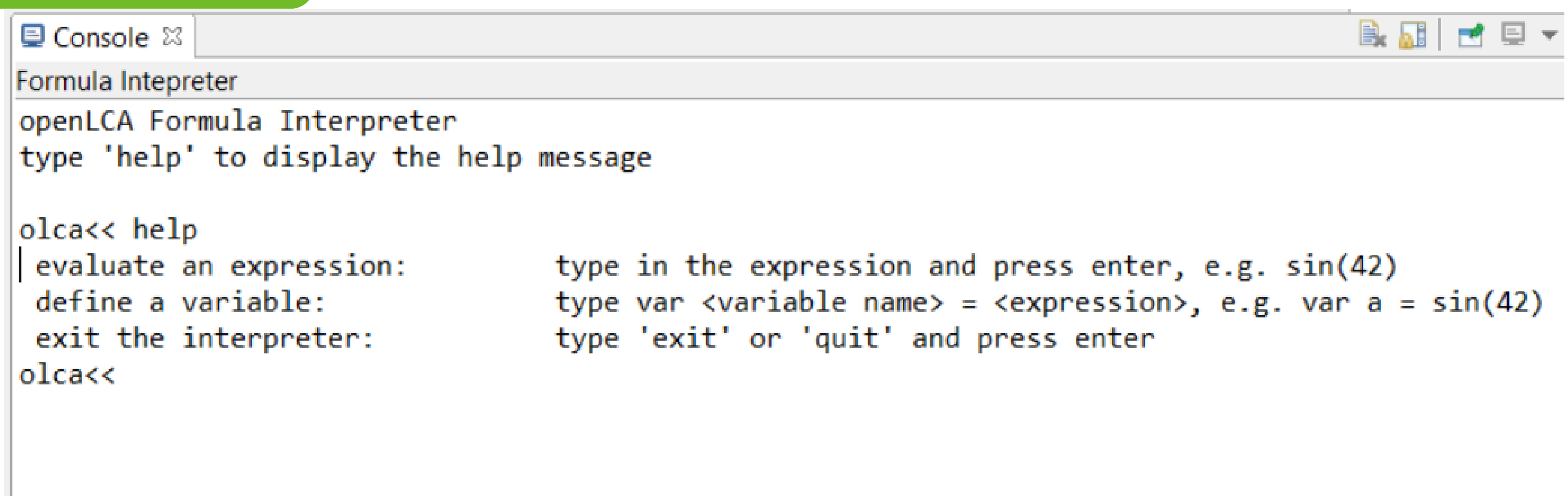
- Parameter names...
  ... must be written with small characters.
  ... must be one word.
  ... cannot contain special characters.
  ... cannot have more than 255 characters.
- Parameter formulas...
  ... can contain single values, simple equations, or complex functions including logical expressions.
  ... 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.

Parameters: checking formulas

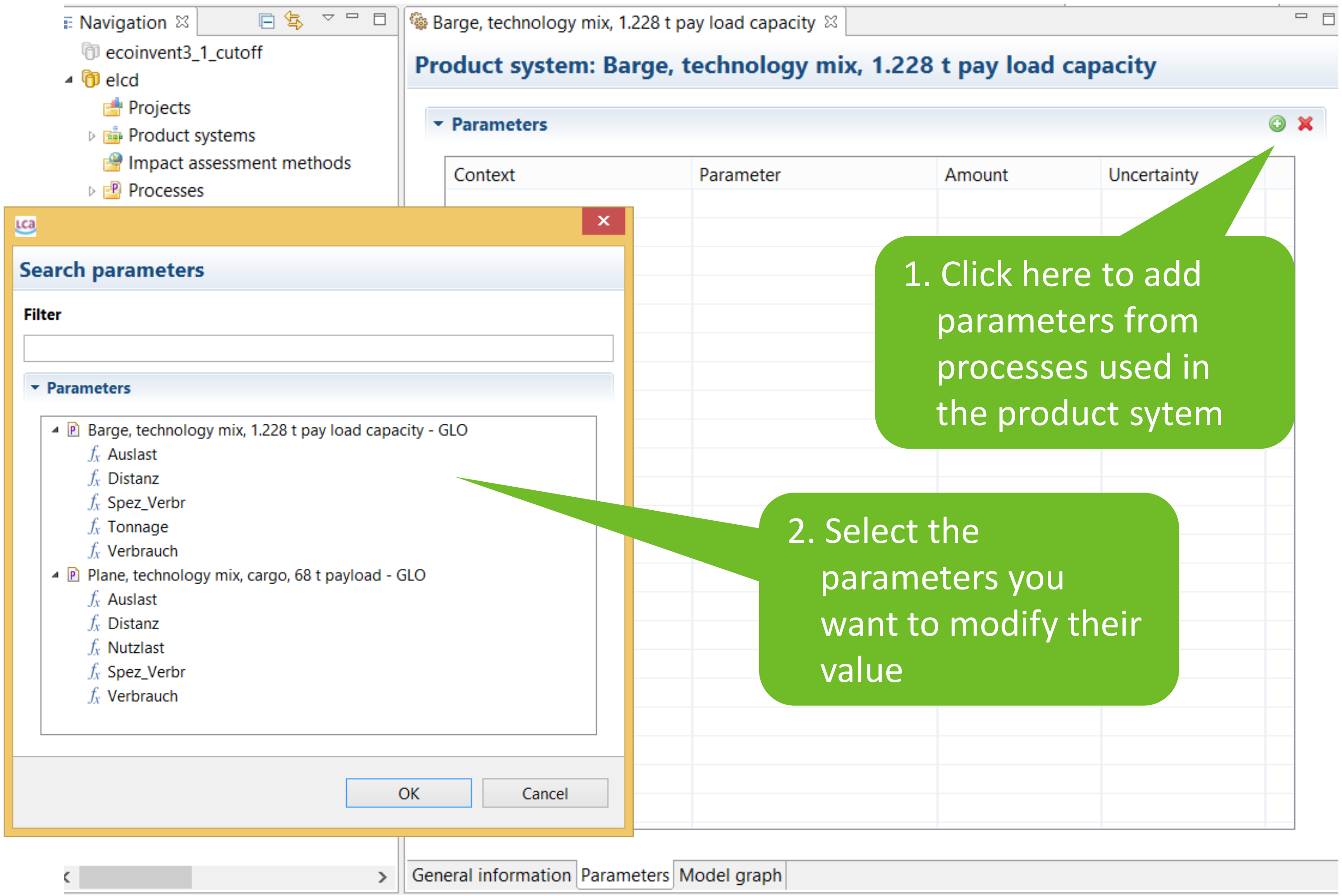
- For complex formulas must use a certain format (e.g. Tan (a), trunc(c), etc.). Use the formula interpreter to find errors.



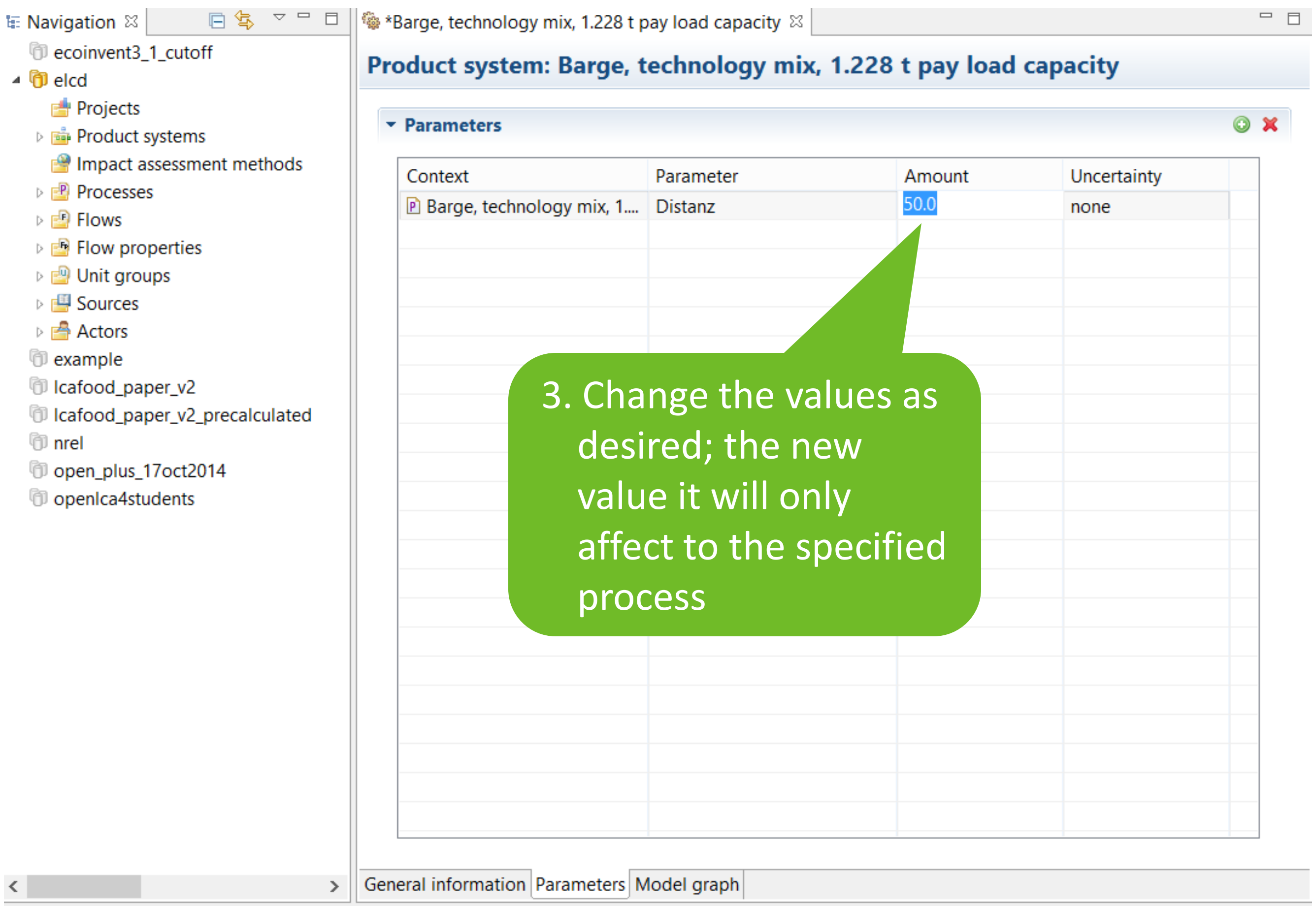
Select “Formula Interpreter” in “Window” menu



Product system: Parameters

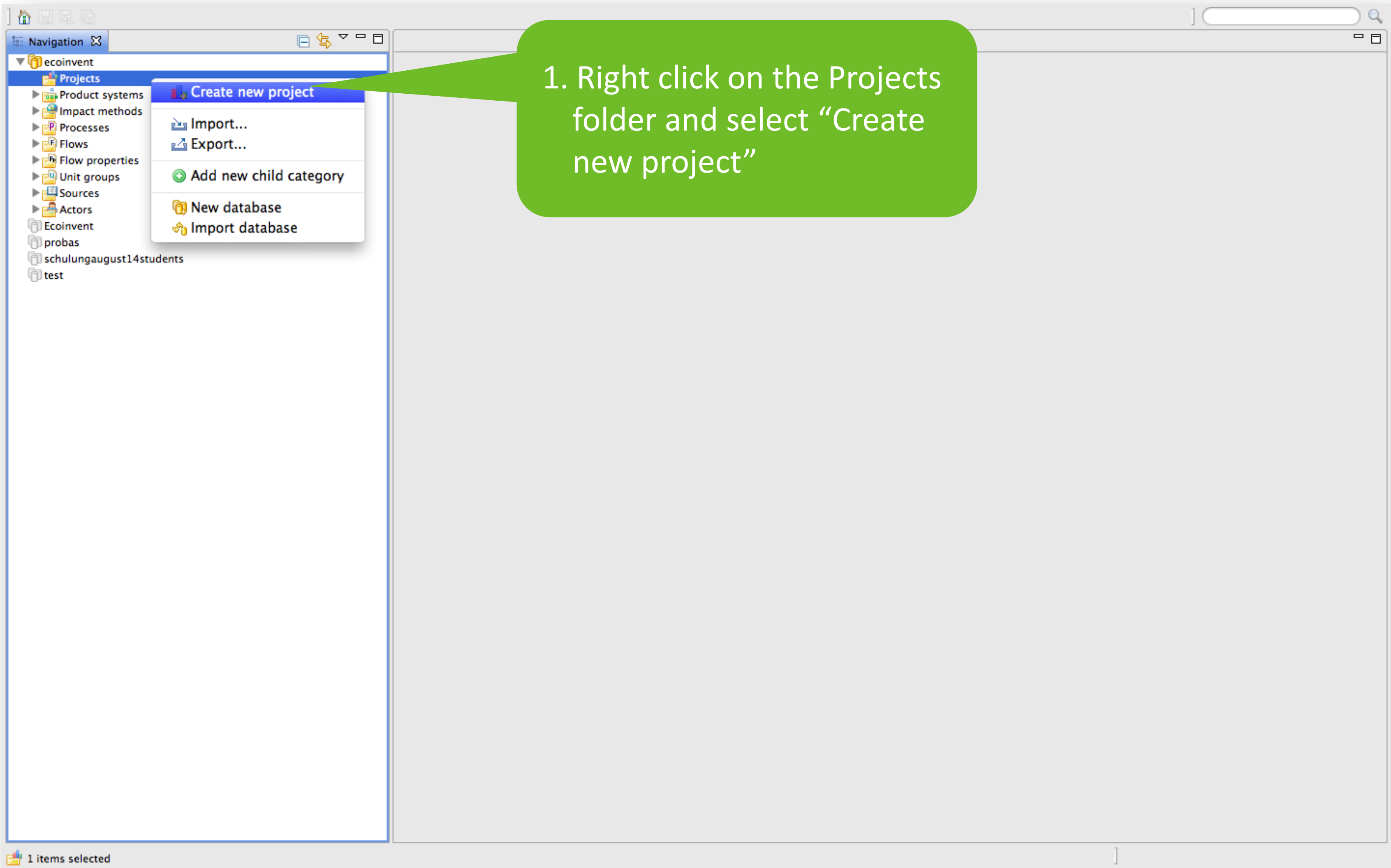


Product system: Parameters



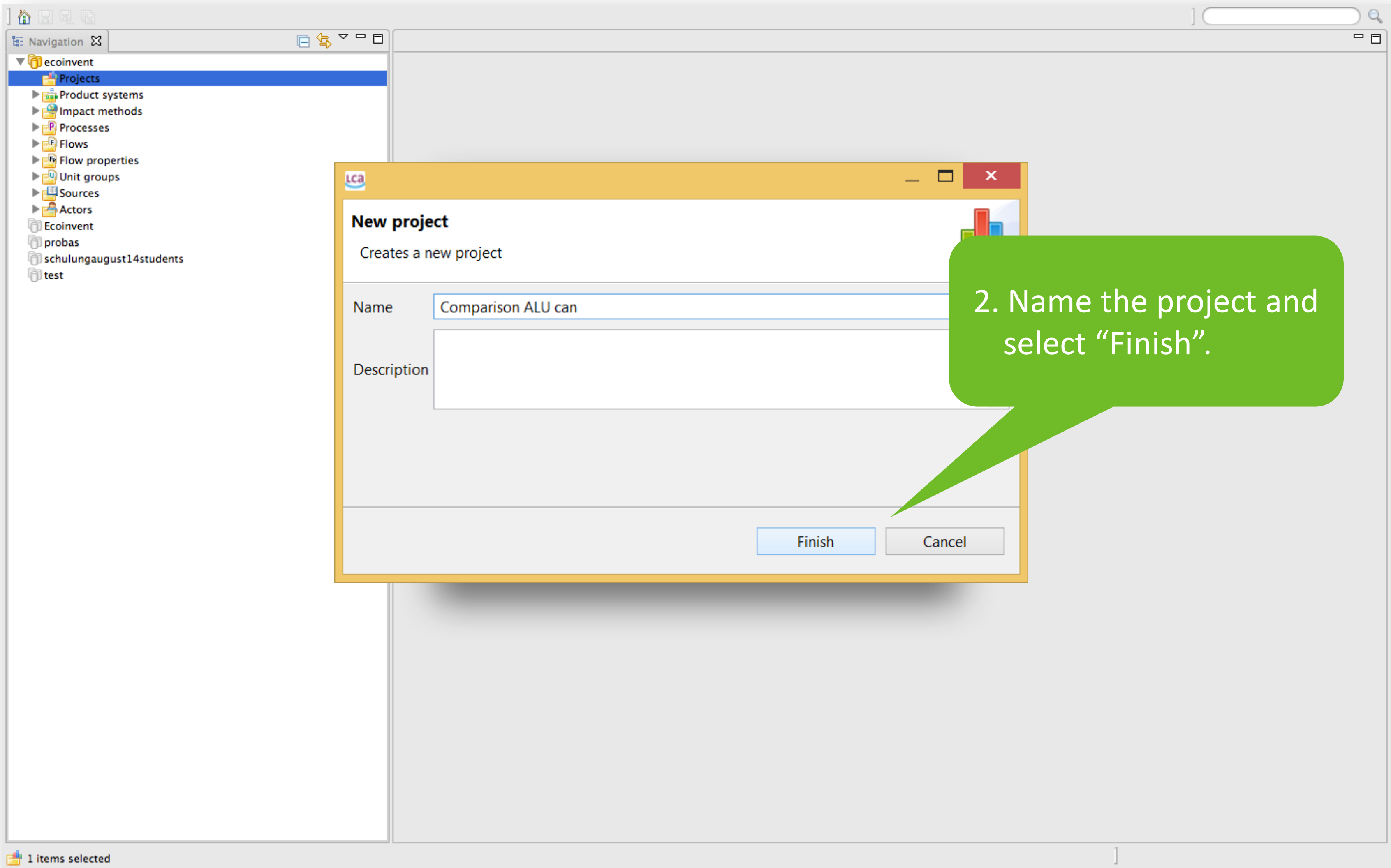
GreenDelta

Project: Creation

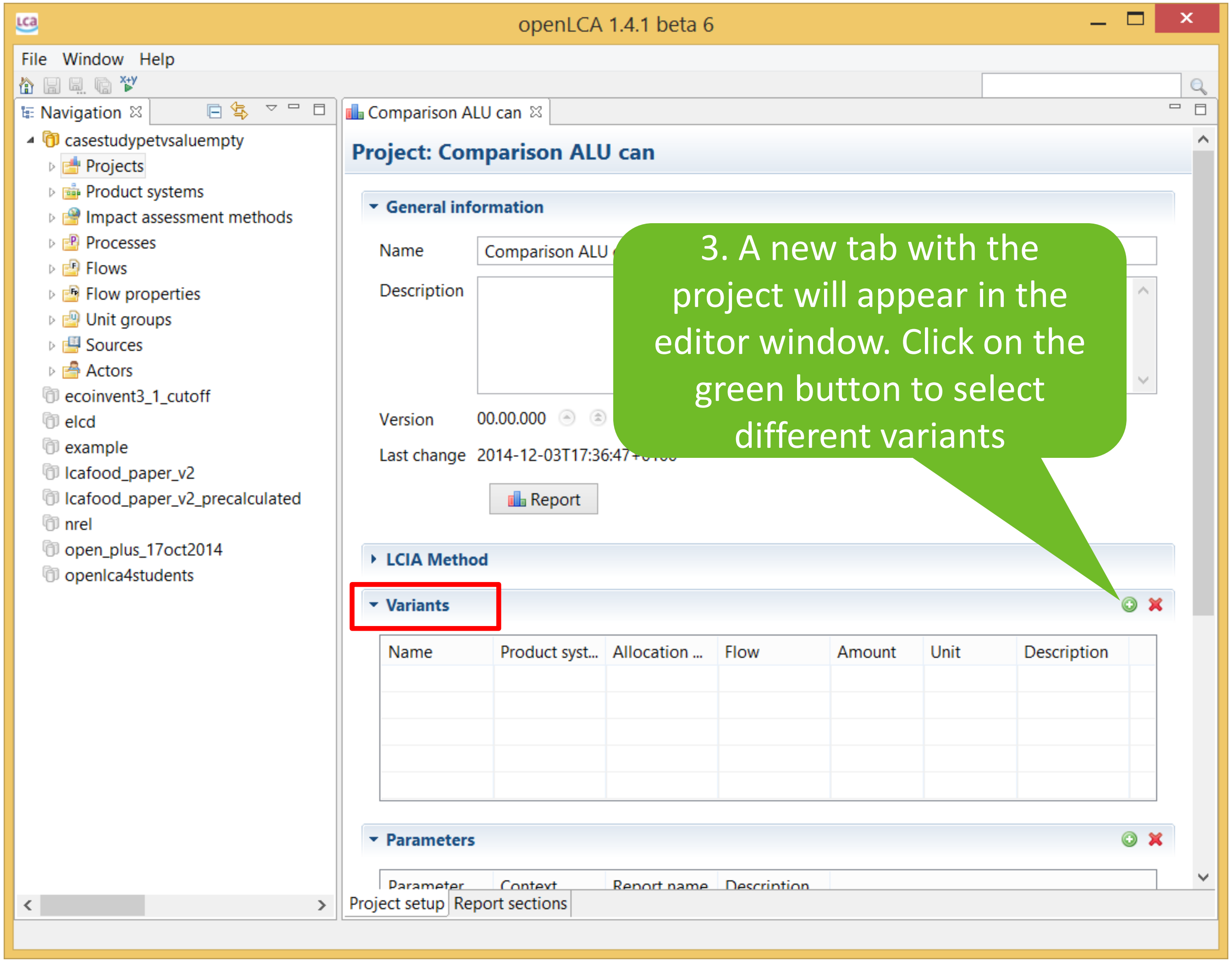


GreenDelta

Project: Creation (II)

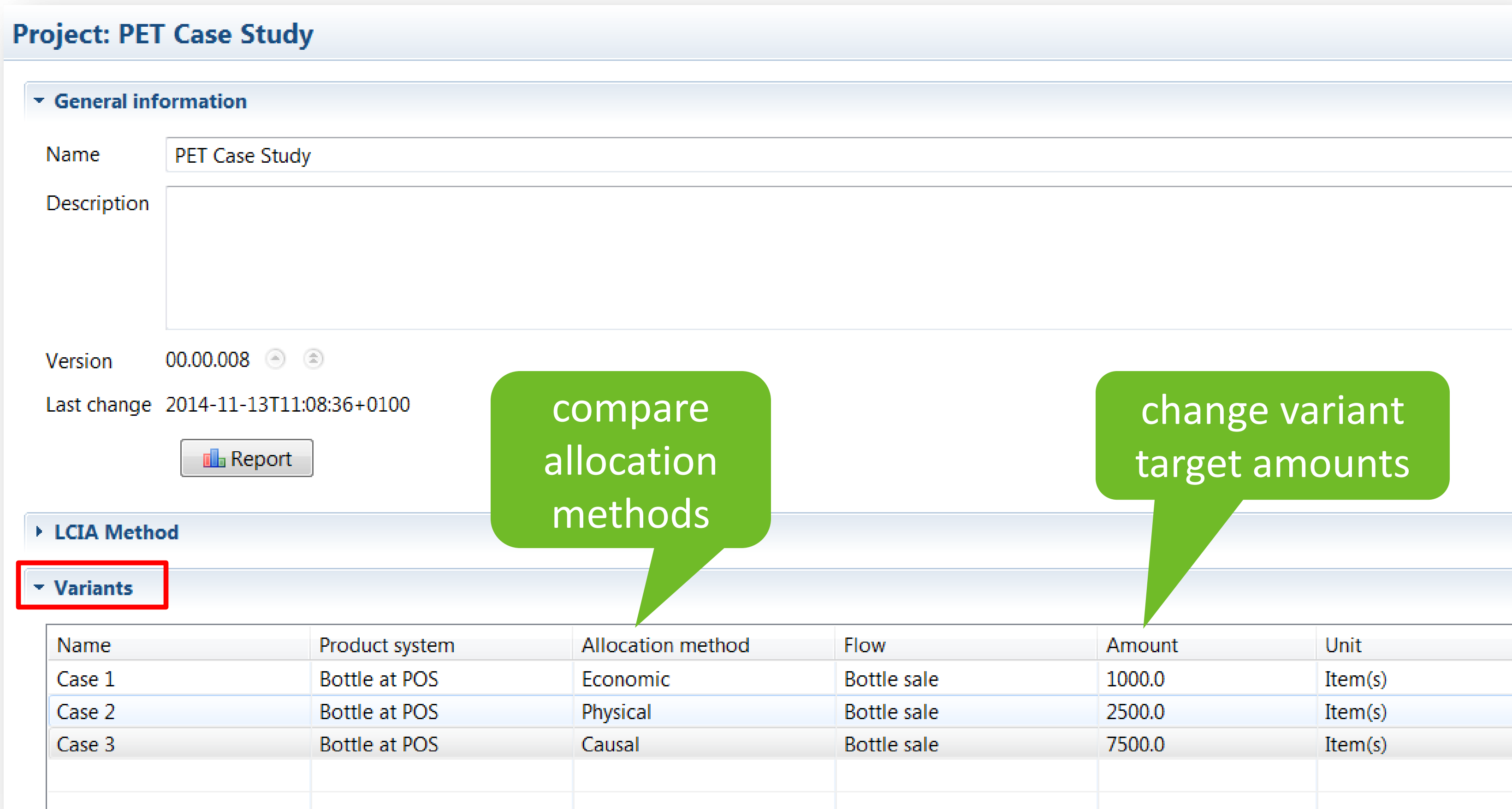


Project: Creation (III)



Comparative assessments: Projects

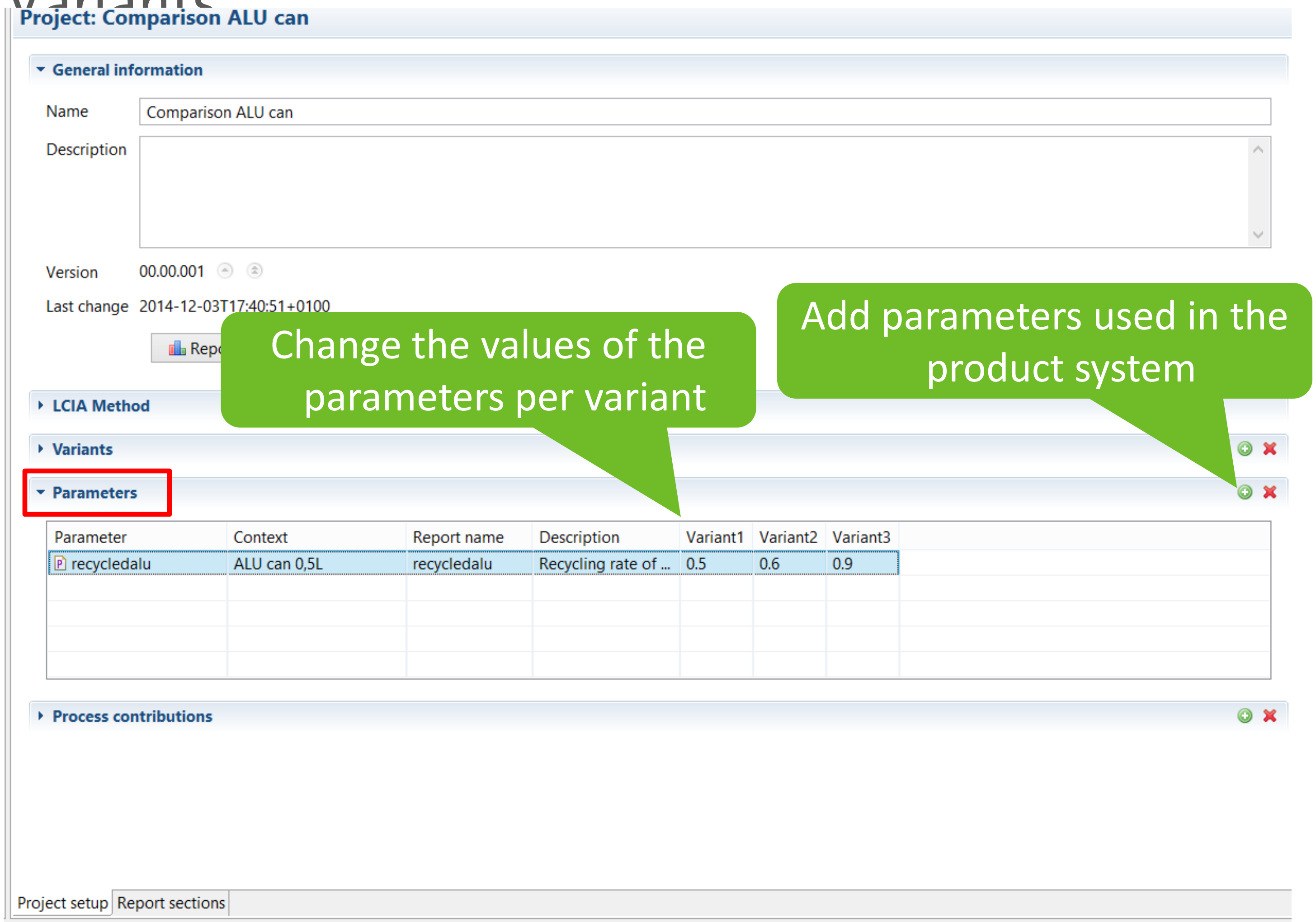
- Same or different product systems can be compared using Variants



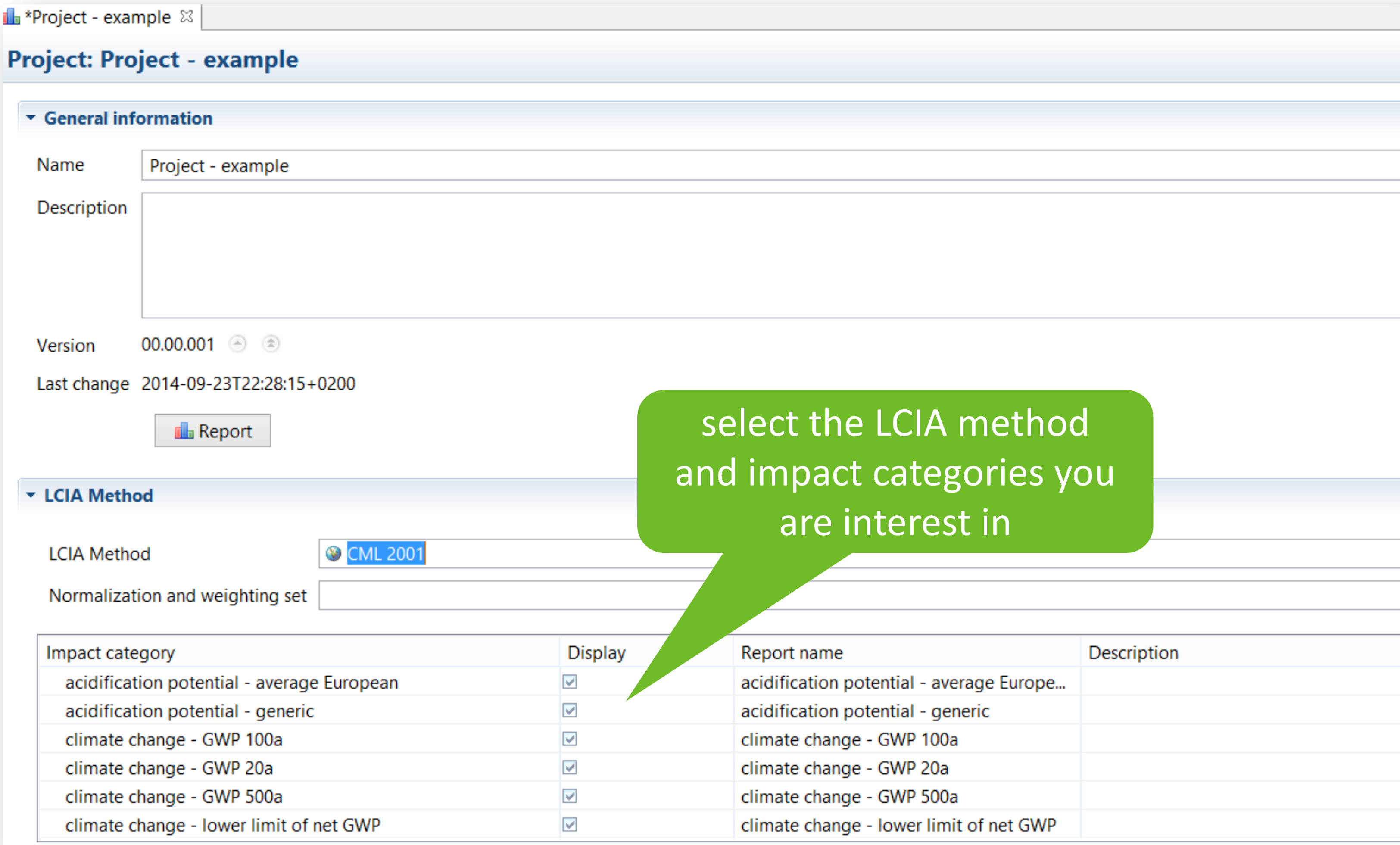
GreenDelta

Comparative assessments: Projects

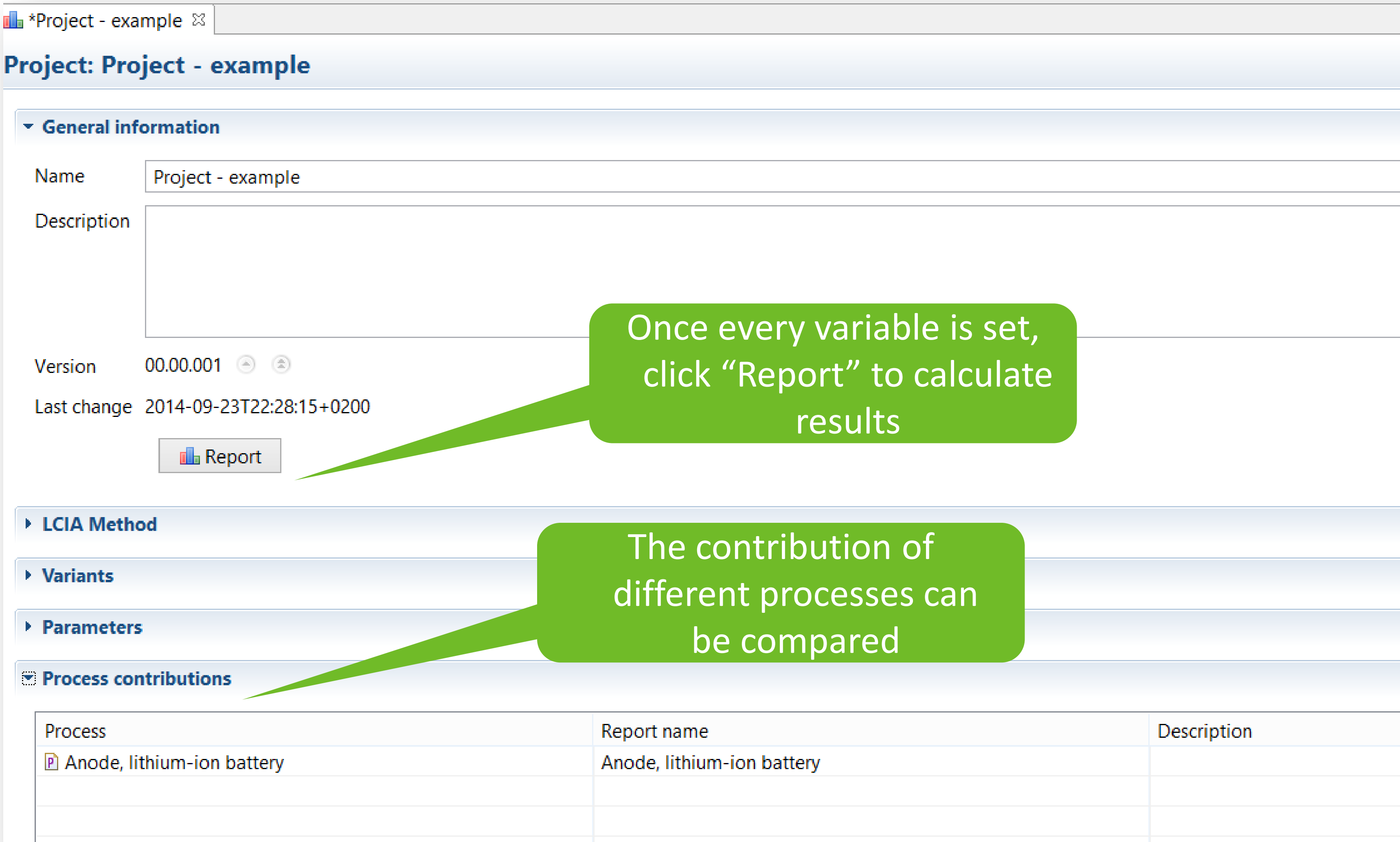
- Same or different product systems can be compared using Variants



Comparative assessments: Projects

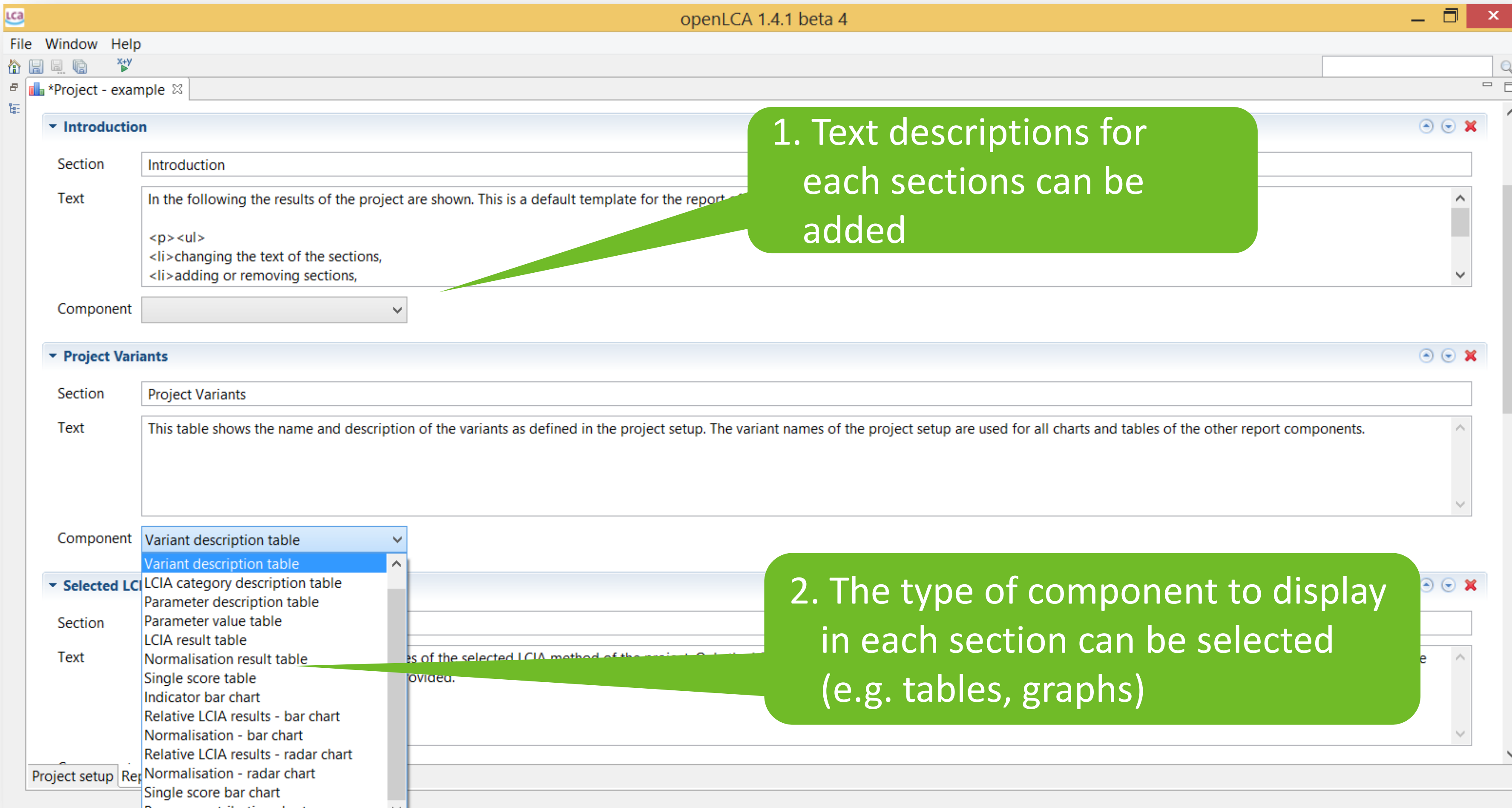


Comparative assessments: Projects



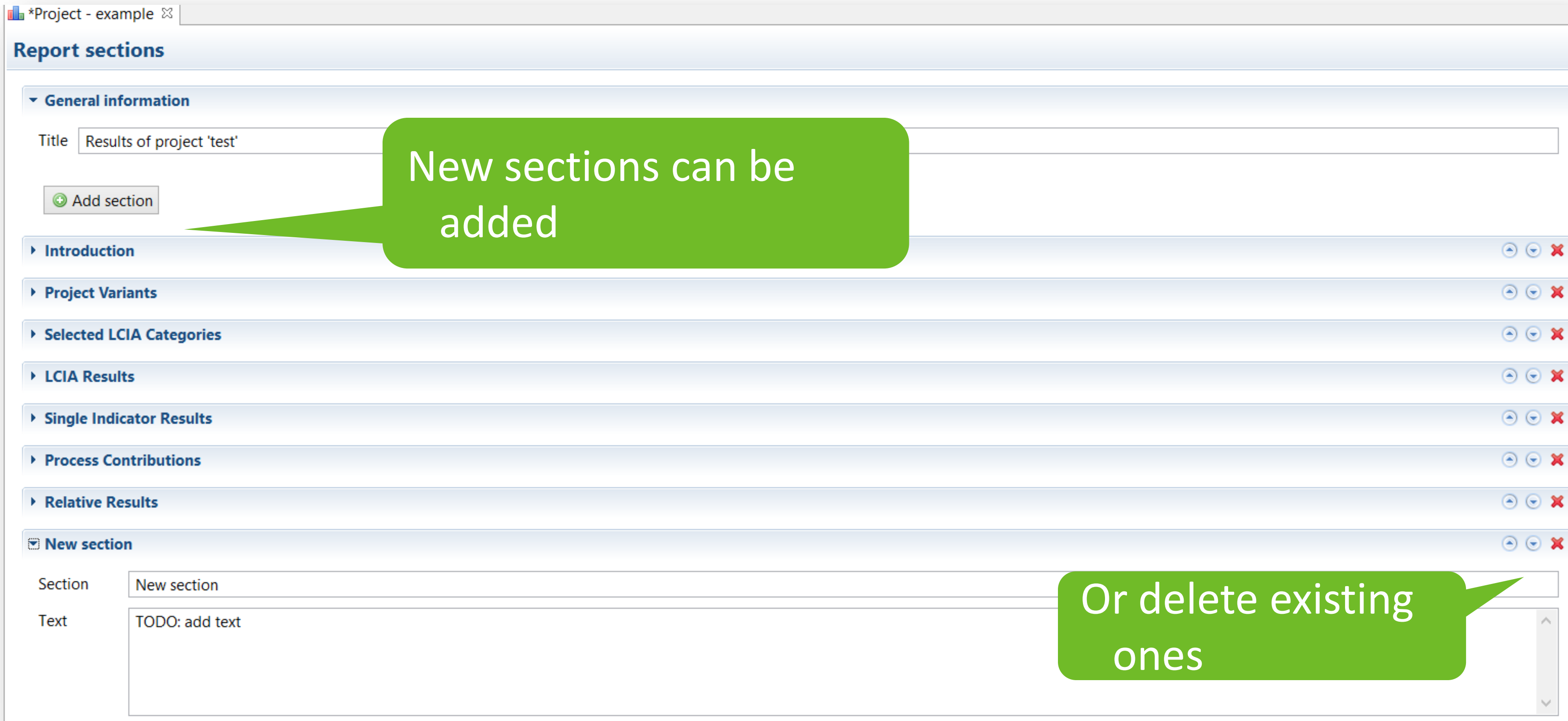
GreenDelta

Project: Report



GreenDeLTa

Project: Report sections



GreenDelta

Example: Project report

*Report-example | Report Viewer | Report Viewer

Variant	Description
Variant1	
Variant2	

Selected LCIA Categories

The table below shows the LCIA categories of the selected LCIA method of the project. Only the LCIA categories that are selected to be displayed are shown in the report. Additionally, a user friendly name and a description for the report can be provided.

LCIA category	Unit	Description
climate change - GWP 100a	kg CO2-Eq	
climate change - GWP 20a	kg CO2-Eq	
climate change - GWP 500a	kg CO2-Eq	

LCIA Results

This table shows the LCIA results of the project variants. Each selected LCIA category is displayed in the rows and the project variants in the columns. The unit is the unit of the LCIA category as defined in the LCIA method.

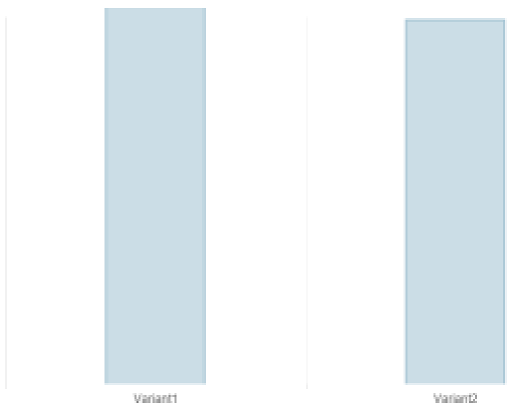
LCIA category	Variant1	Variant2	Unit
climate change - GWP 100a	-1.35354e+2	-9.02359e+1	kg CO2-Eq
climate change - GWP 20a	-1.38358e+2	-9.22388e+1	kg CO2-Eq
climate change - GWP 500a	-1.33922e+2	-8.92811e+1	kg CO2-Eq

Example: Project report

Single Indicator Results

The following chart shows the single results of each project variant for the selected indicator. You can change the selection and the chart is dynamically updated.

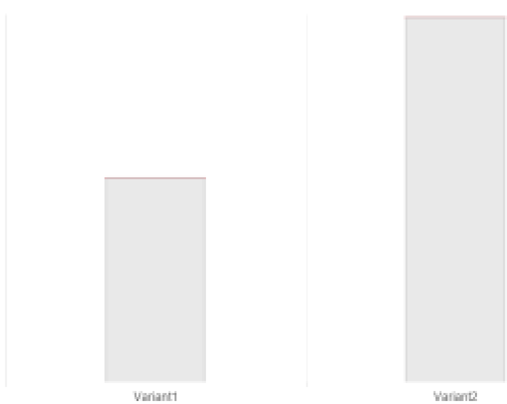
climate change - GWP 100a ▼



Process Contributions

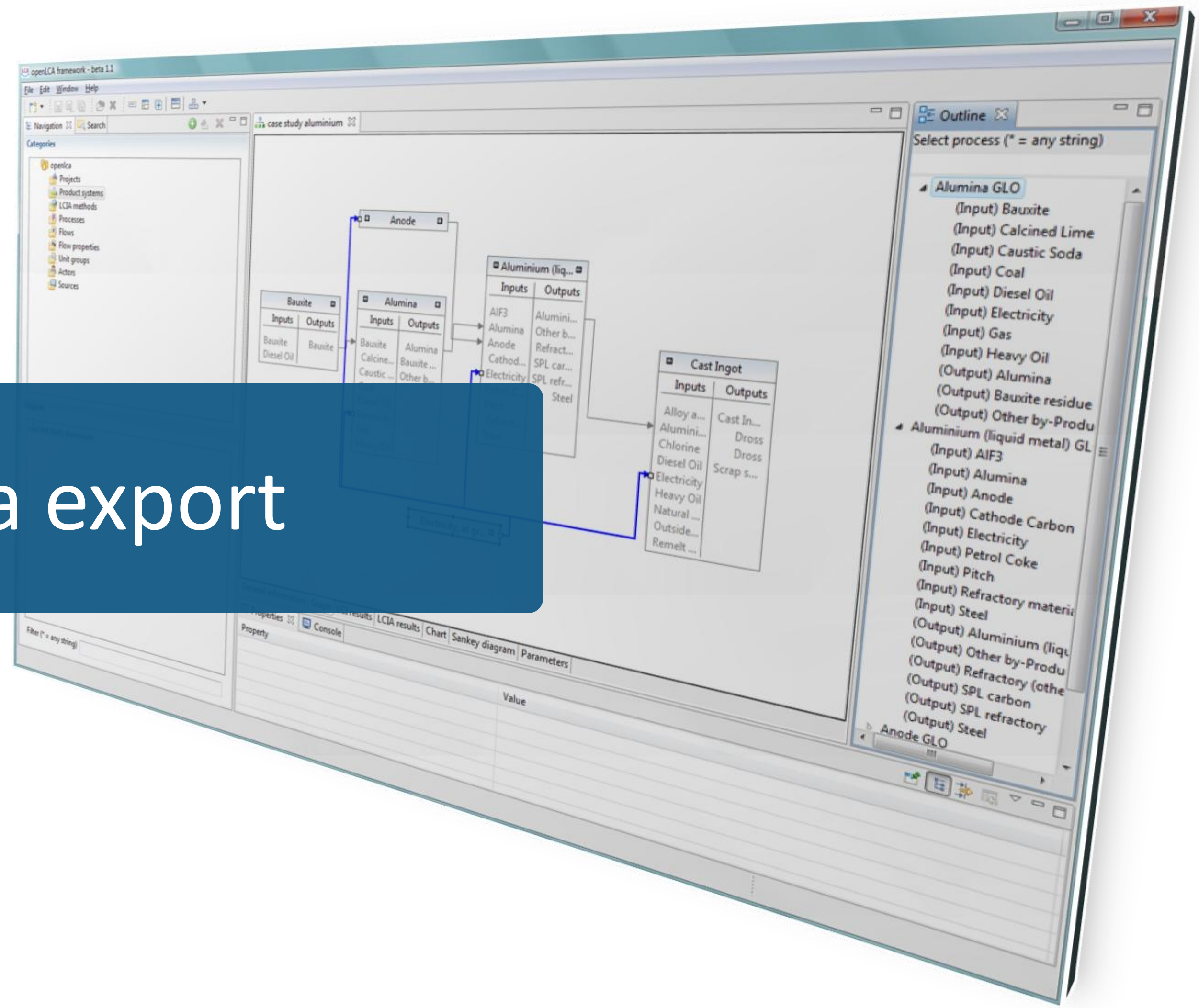
This chart shows the contributions of the selected processes in the project setup to the variant results of the selected LCIA category. As for the single indicator results, you can change the selection and the chart is dynamically updated.

climate change - GWP 100a ▼



GreenDelta

Data export


Outline
Select process (* = any string)
Alumina GLO
(Input) Bauxite
(Input) Calcined Lime
(Input) Caustic Soda
(Input) Coal
(Input) Diesel Oil
(Input) Electricity
(Input) Gas
(Input) Heavy Oil
(Output) Alumina
(Output) Bauxite residue
Anode
Bauxite
Alumina
Cast Ingot
Inputs
Outputs
case study aluminium
Console
LCIA results
Chart
Sankey diagram
Parameters
Value

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

Excel export

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

Other export formats

CSV-Matrix

- Graph of a product system

Images

- Diagrams

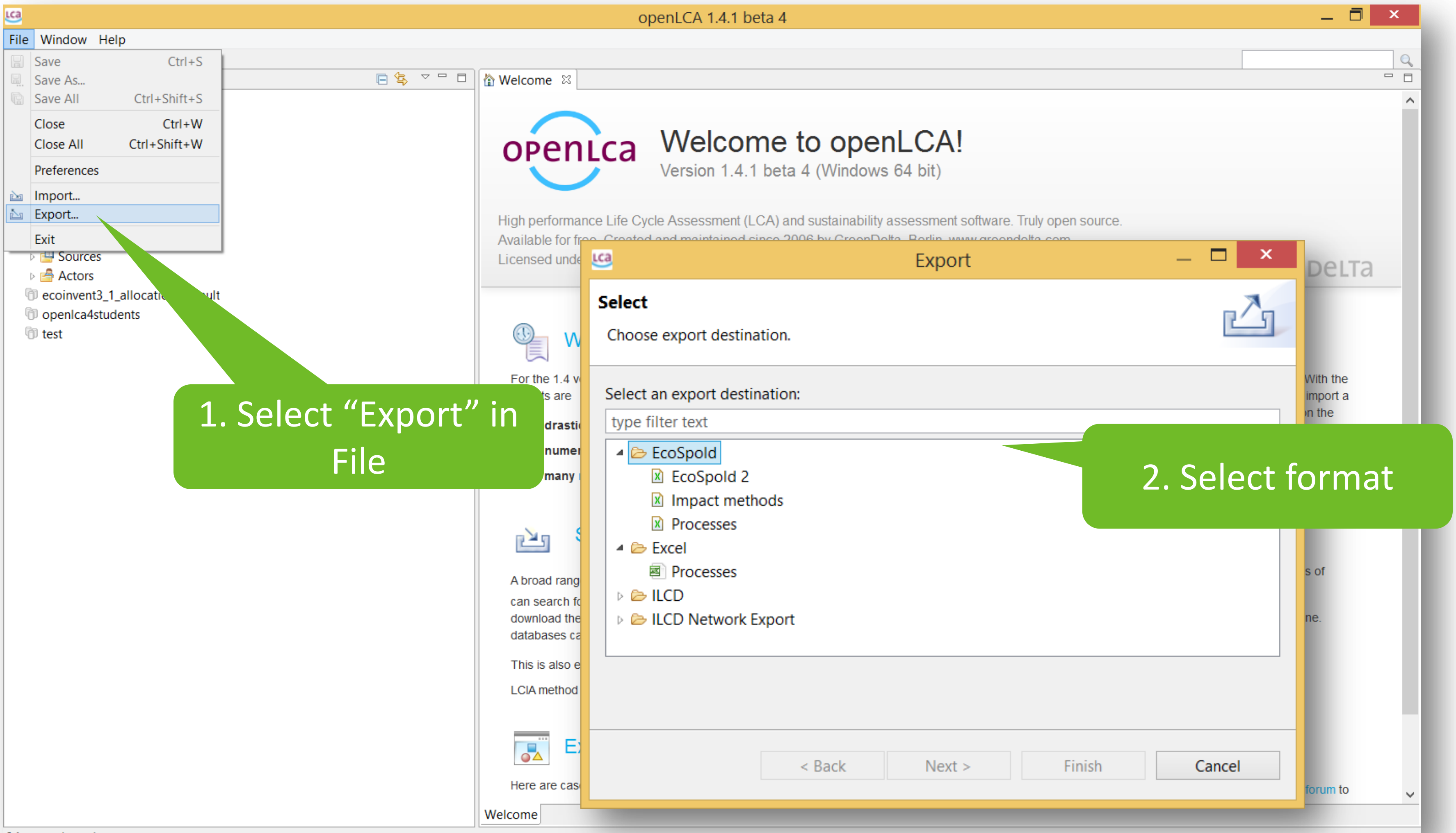
HTML

- Project report

openLCA script (.zolca)

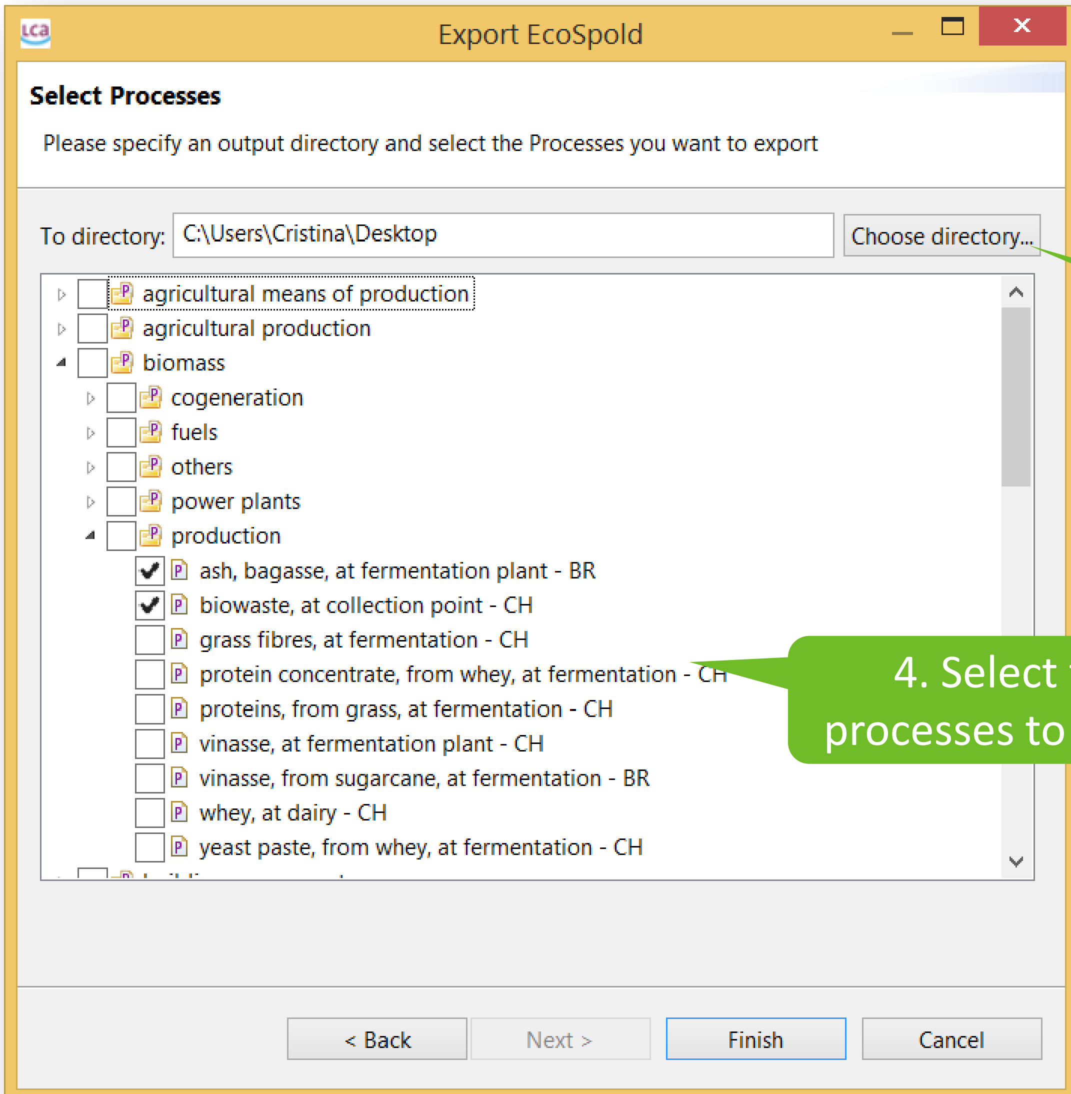
- Complete databases

Example: process export (I)



GreenDelta

Example: process export (II)

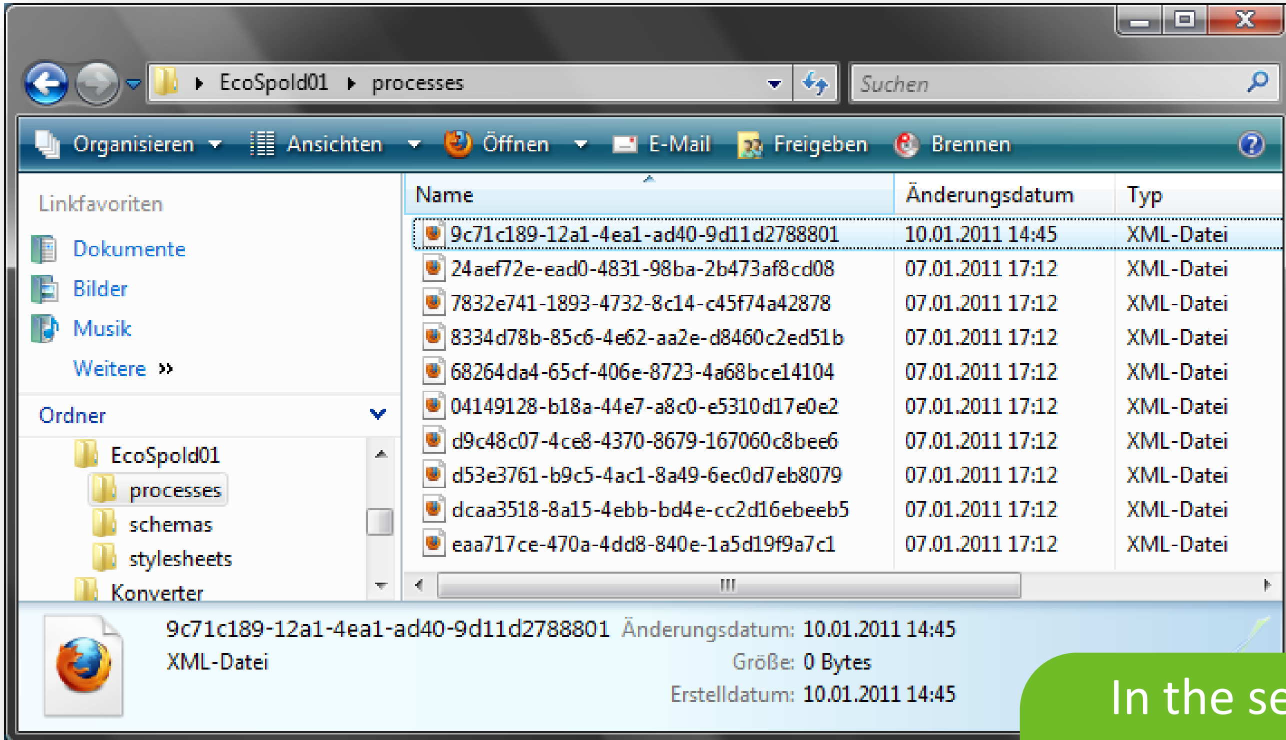


3. Select the directory where data will be stored

4. Select the processes to export

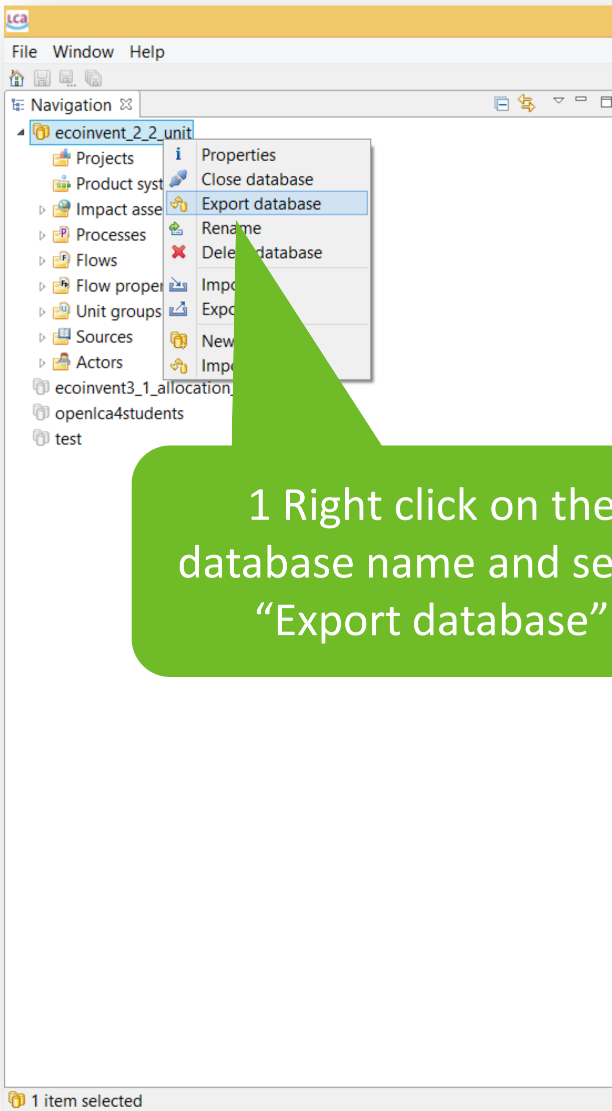
GreenDelta

Example: process export (III)

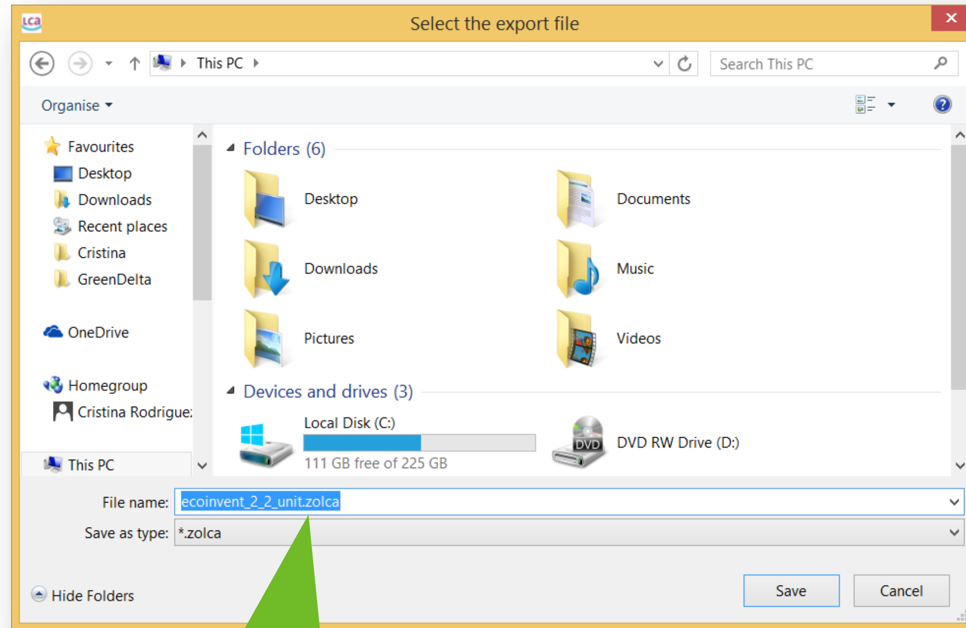


In the selected directory a folder with the name of the export format is created. For instance, Desktop\ EcoSpold01\ processes

Export openLCA database



1 Right click on the database name and select “Export database”



2. Select the directory and name for the .zolca file

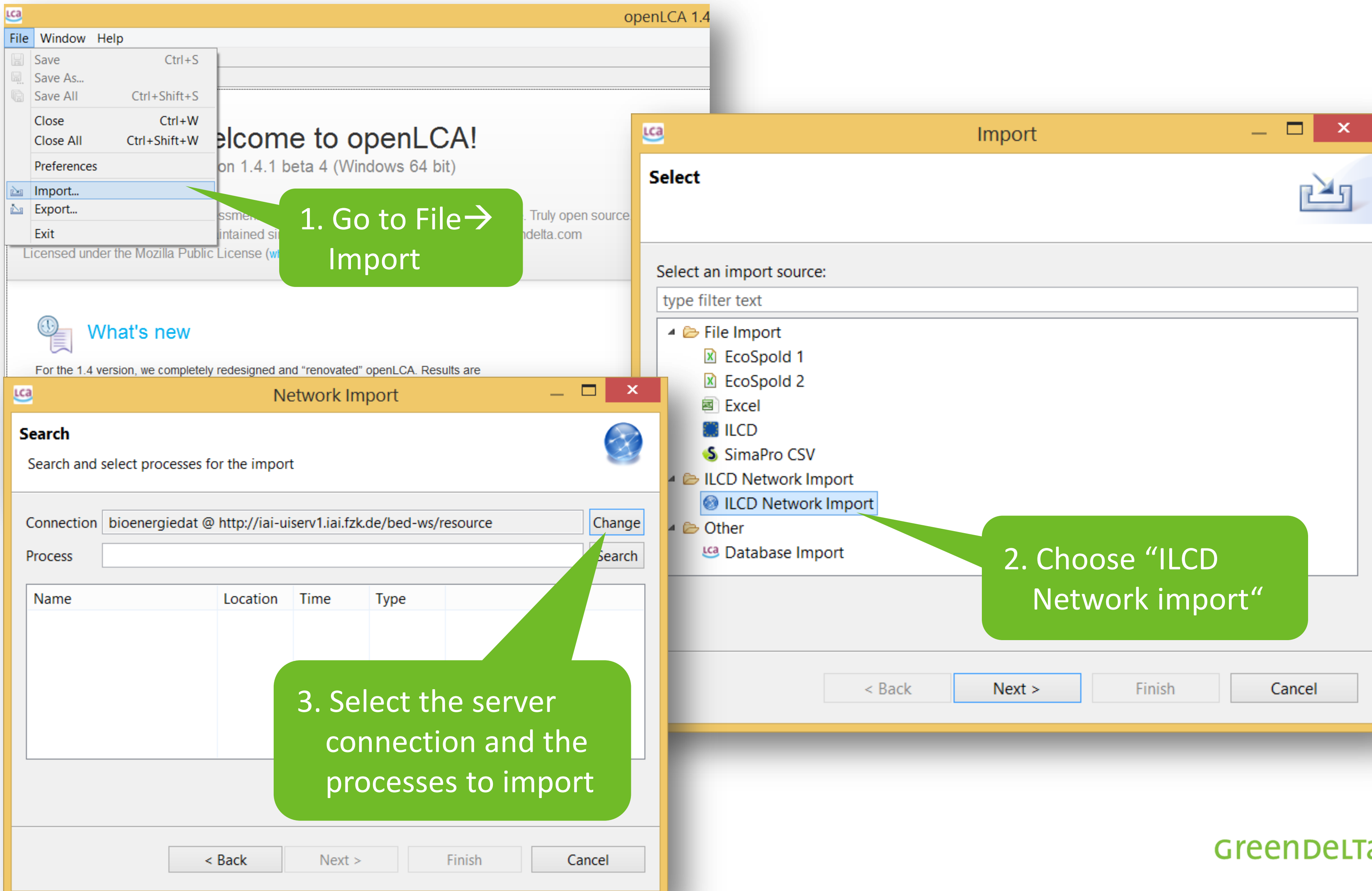
GreenDelta

Using an ILCD network database

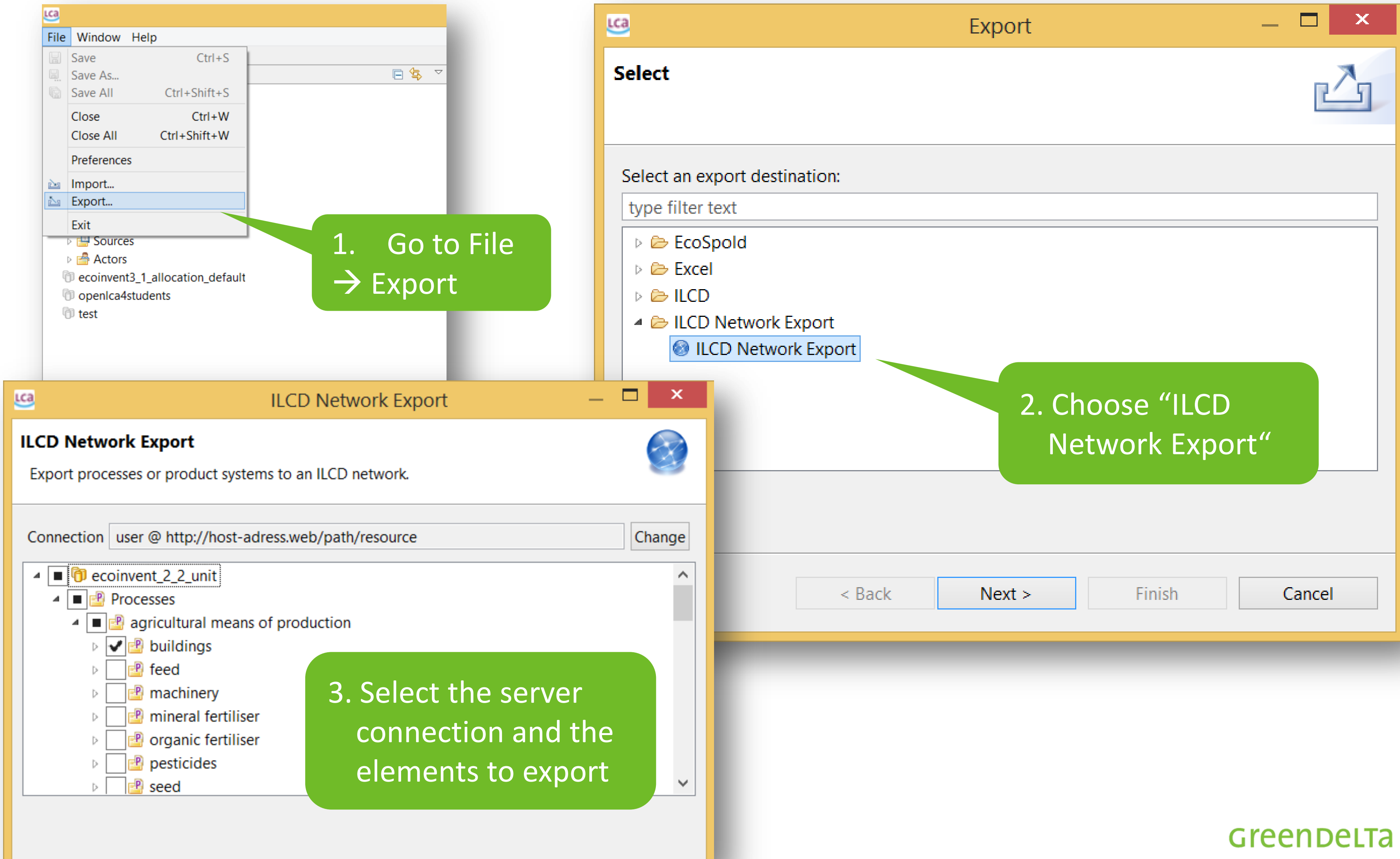
- Useful if more than one person is working on one study.

- Data isuploaded into a database on a server and can be downloaded from each user with access to the server.

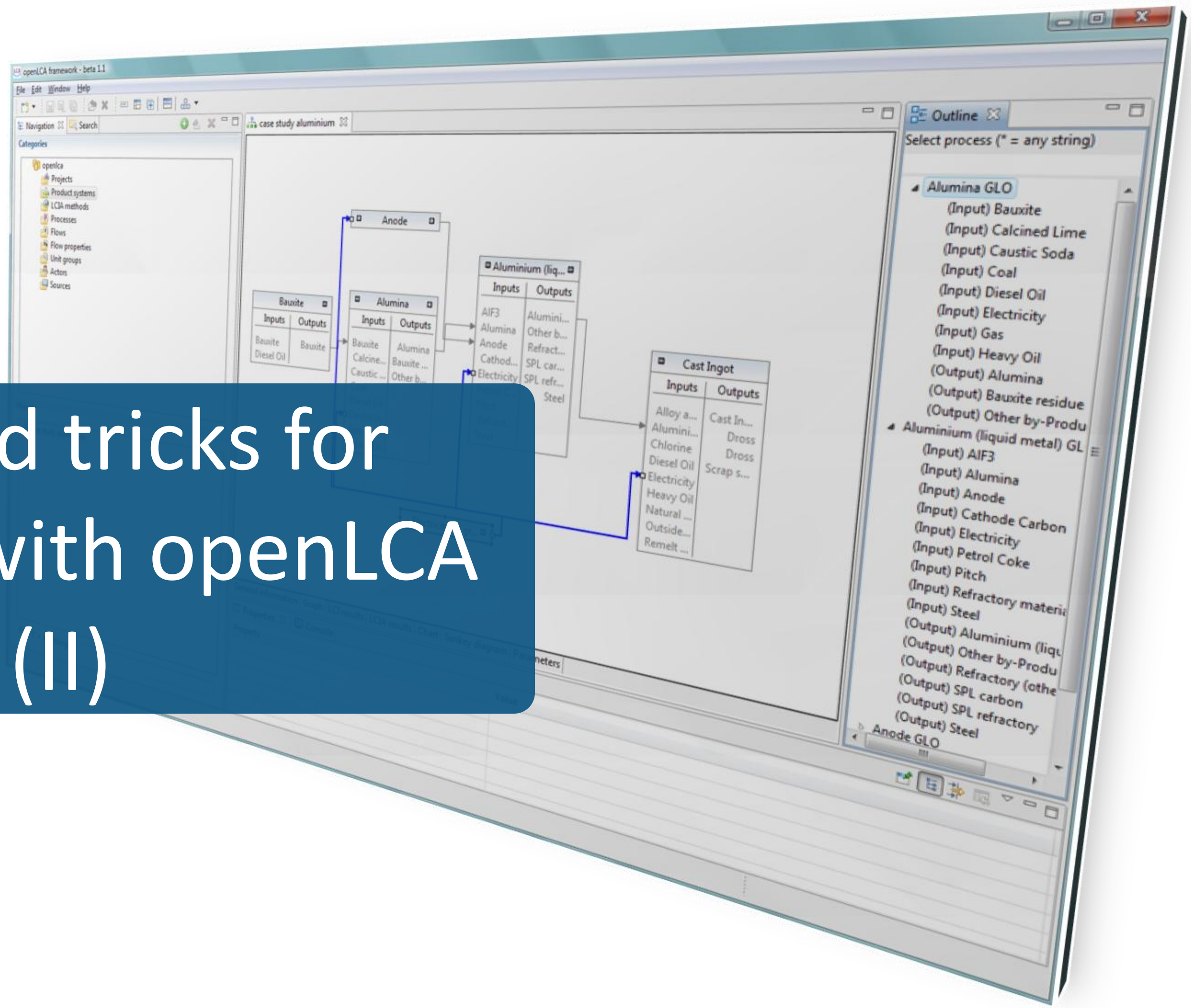
ILCD network database: import



ILCD network database: export

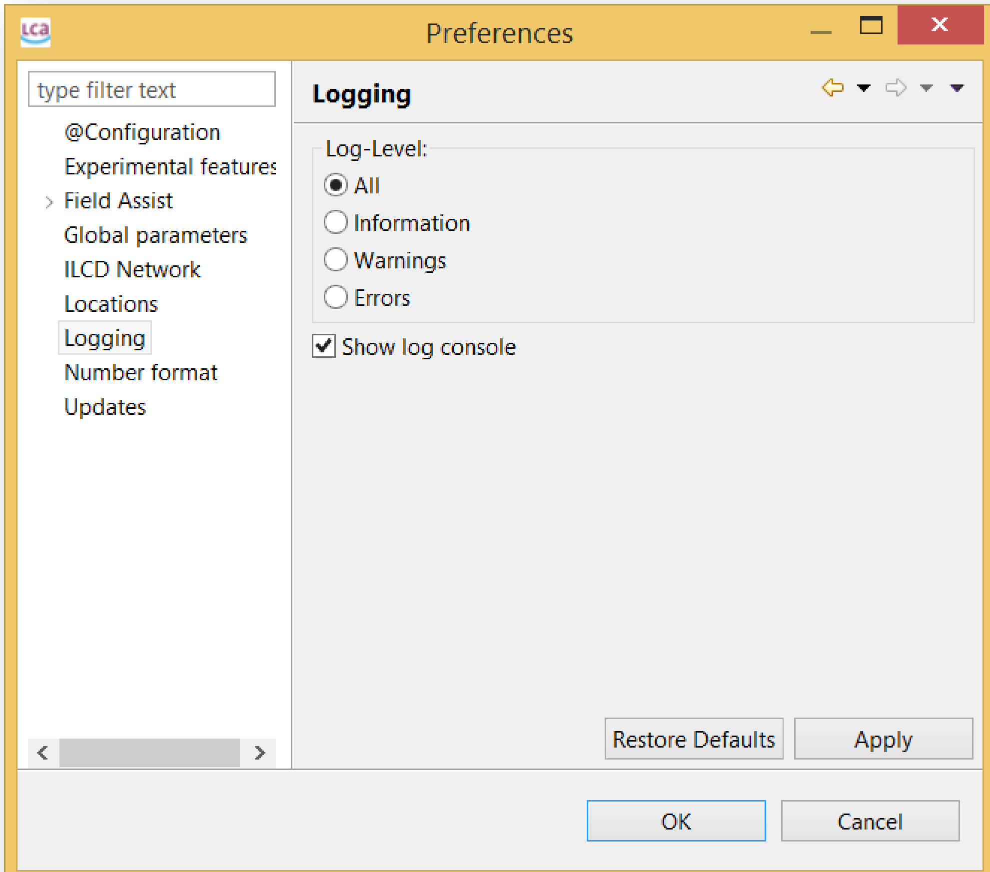


Tips and tricks for working with openLCA (II)



Errors

- It is possible to report all errors in a log file automatically
- To do so go to file/prefreneces/logging and check „All“

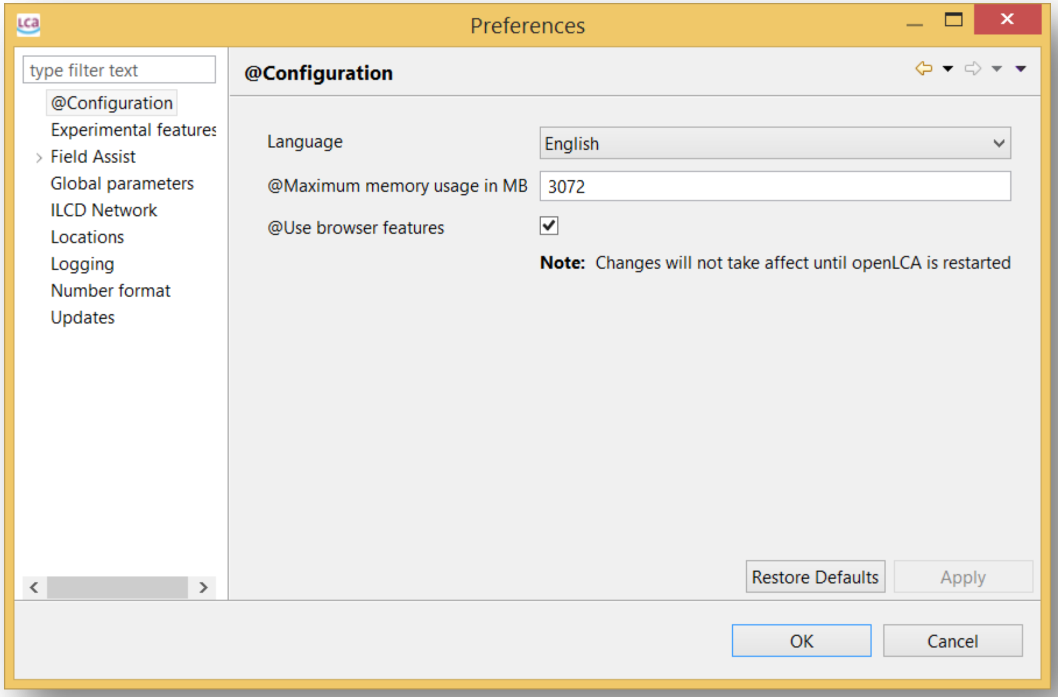


The log file is rewritten every time openLCA is restarted!

GreenDelta

Language

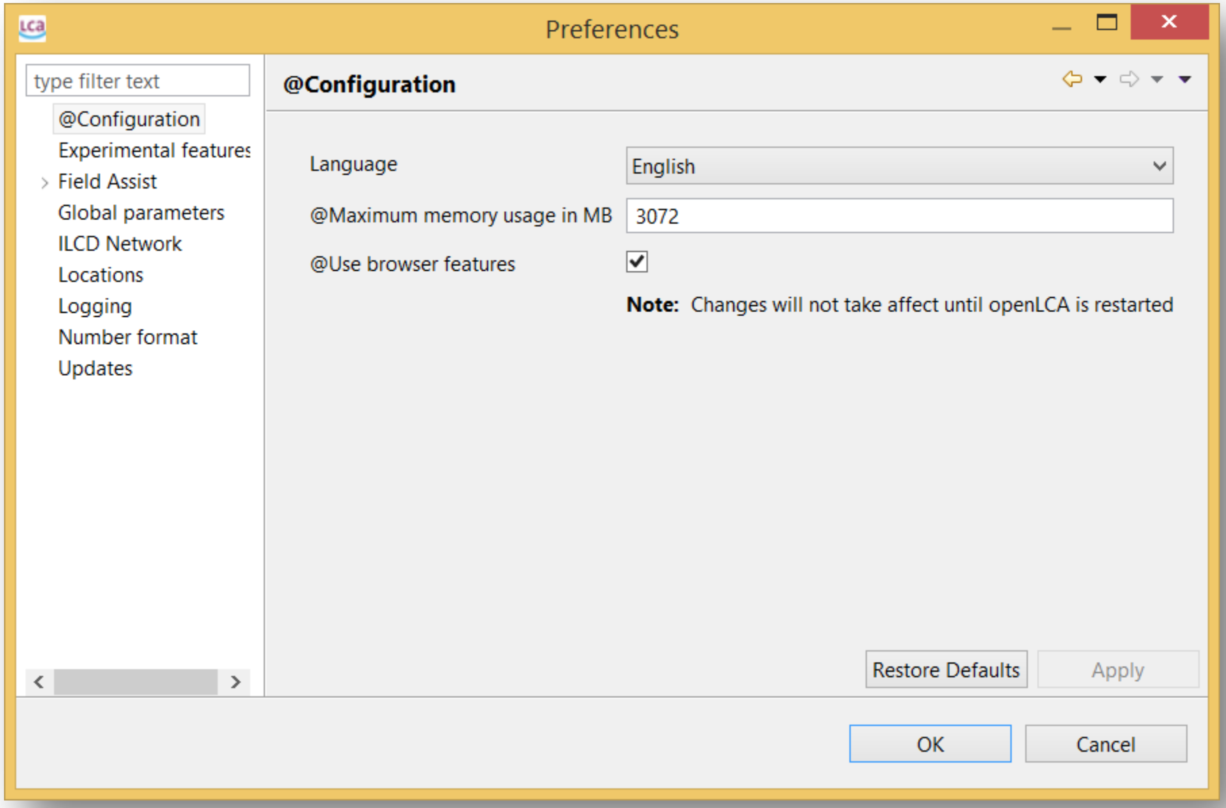
- openLCA is available in Bulgarian, Chinese, English, French, German, Italian and Spanish
- Change it under File/Preferences/@Configuration.
- once you change the language, restart the program to activate it



GreenDelta

Memory usage

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



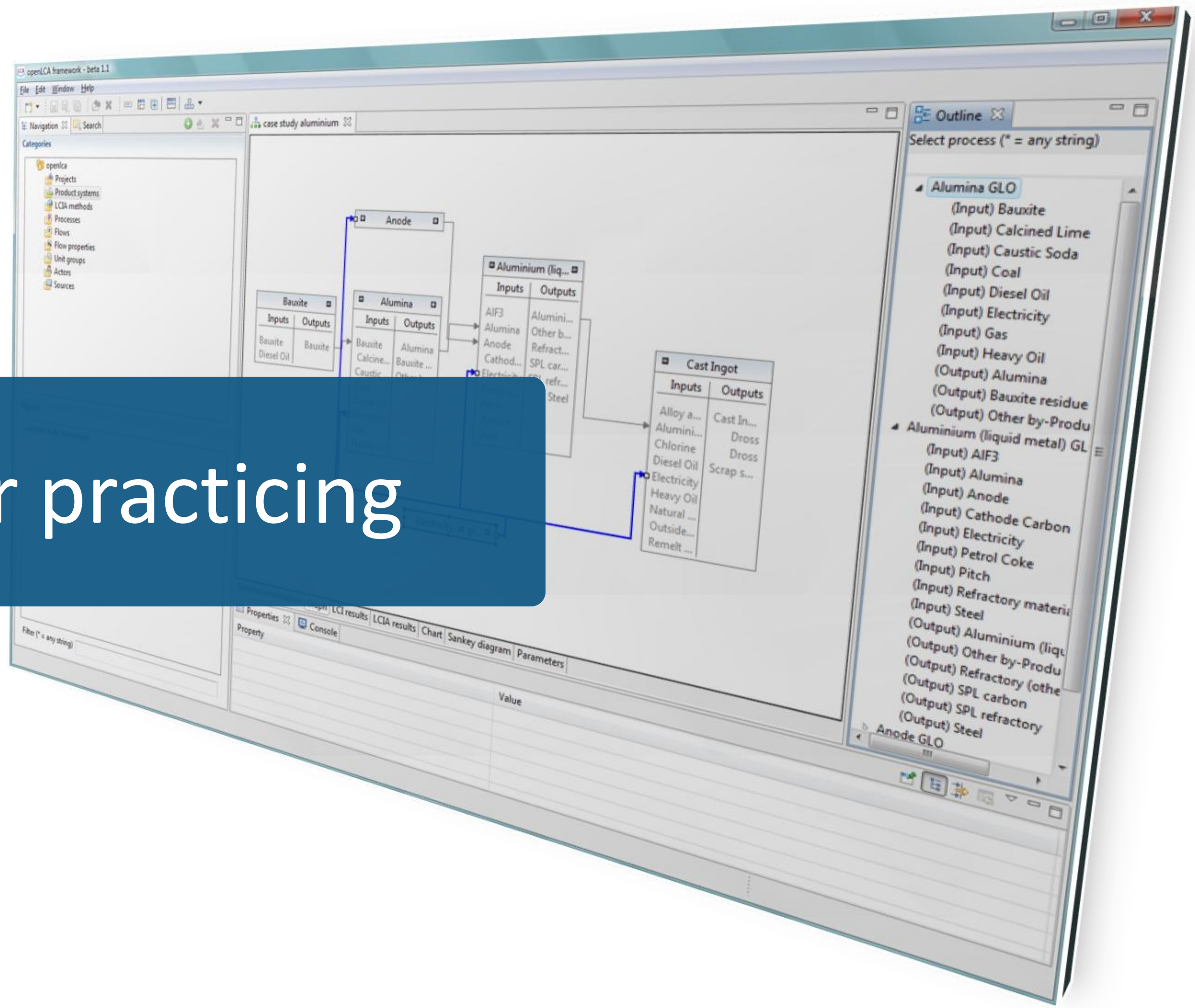
GreenDelta

openLCA-data directory

- The openLCA-data folder is automatically created under 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
```

Further practicing



Excercise 6: Modeling
LCA of PET bottles

Goal: Conduct an LCA of PET water bottles produced and consumed in Germany from cradle to point of sale

FU: 1,000 1-litre still water bottles

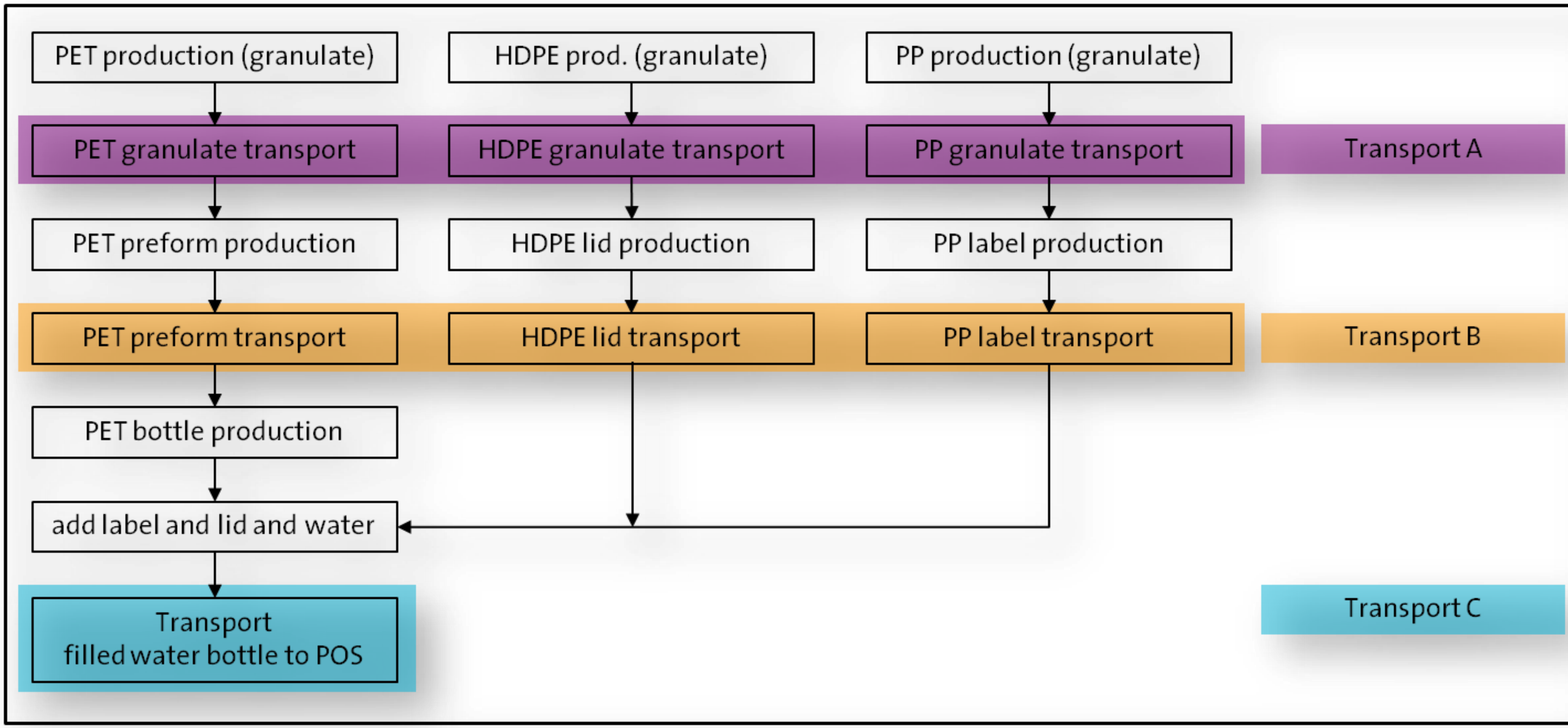
Production chain:

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 preform, lid and label to bottle-filling location (Transport B)
5. Blow PET preform, fill with water and attach lid and label
6. Transport of the filled water bottle to retailers (Transport C)

GreenDelta

Excercise 6: Modeling
LCA of PET bottles

Supply chain and system boundary:



Excercise 6: Modeling

LCA of PET bottles

Case-study assumptions (I):

- For the production of the bottles, lids and labels, it is assumed that 100% of the respective input granulate is utilized in forming the final product, without waste.

	PET	HDPE	PP	Empty bottle	Water	Full bottle
Weight	60 g	4g	1g	65g	1kg	1.065kg

- Water used to fill bottles (ELCD database): “surface water at a water purification plant (RER)”

- Information on the amount of energy required to run the machines which produce the PET pre-forms, PP labels, HDPE lids as well as those required to make the final PET bottles and add the lid, label and fill with water is not available and will be ‘ignored’ for modeling purposes.

Excercise 6: Modeling
LCA of PET bottles

Case-study assumptions (II):

- Transport (ELCD database): “Euro 0, 1, 2, 3, 4 mix, 22 t total weight, 17.3 t max payload – RER”

	Amount	Weight transported
Transport A	200km	0.065kg
Transport B	200km	0.065kg
Transport C	50km	1.065kg

Excercise 6: Modeling
LCA of PET bottles

check default providers!

Task: Model the supply chain of PET water bottles from cradle to gate using the ELCD database:

a) Create separate unit processes for each of the six steps of the production chain

b) Create one process containing all of the flows in the production chain

c) Create product systems from a) and b), respectively, and compare the model graphs

Before starting the task, download the ELCD database from openLCA Nexus, as well as the openLCA LCIA method pack available at openlca.org/downloads and import them both into openLCA.

Excercise 6: Modeling
LCA of PET bottles – Model graphs

vs.

Excercise 6: Modeling
LCA of PET bottles

d) Calculate the product system using the LCIA method ReciPe Midpoint (H) and the normalization/weighting set “Europe ReciPe Midpoint (H)”

- What‘s the climate change impact of the product system relative to the total annual impact of CC per person in Europe? Check values also for terrestrial acidification & ionising radiation.

- Which impact category has the highest contribution to the overall impact of the production of PET water bottles in Germany?

- How do the normalized impacts of the product system change considering the impact of the total European population in the year 2000 in each impact category (instead of impacts/person/year)?

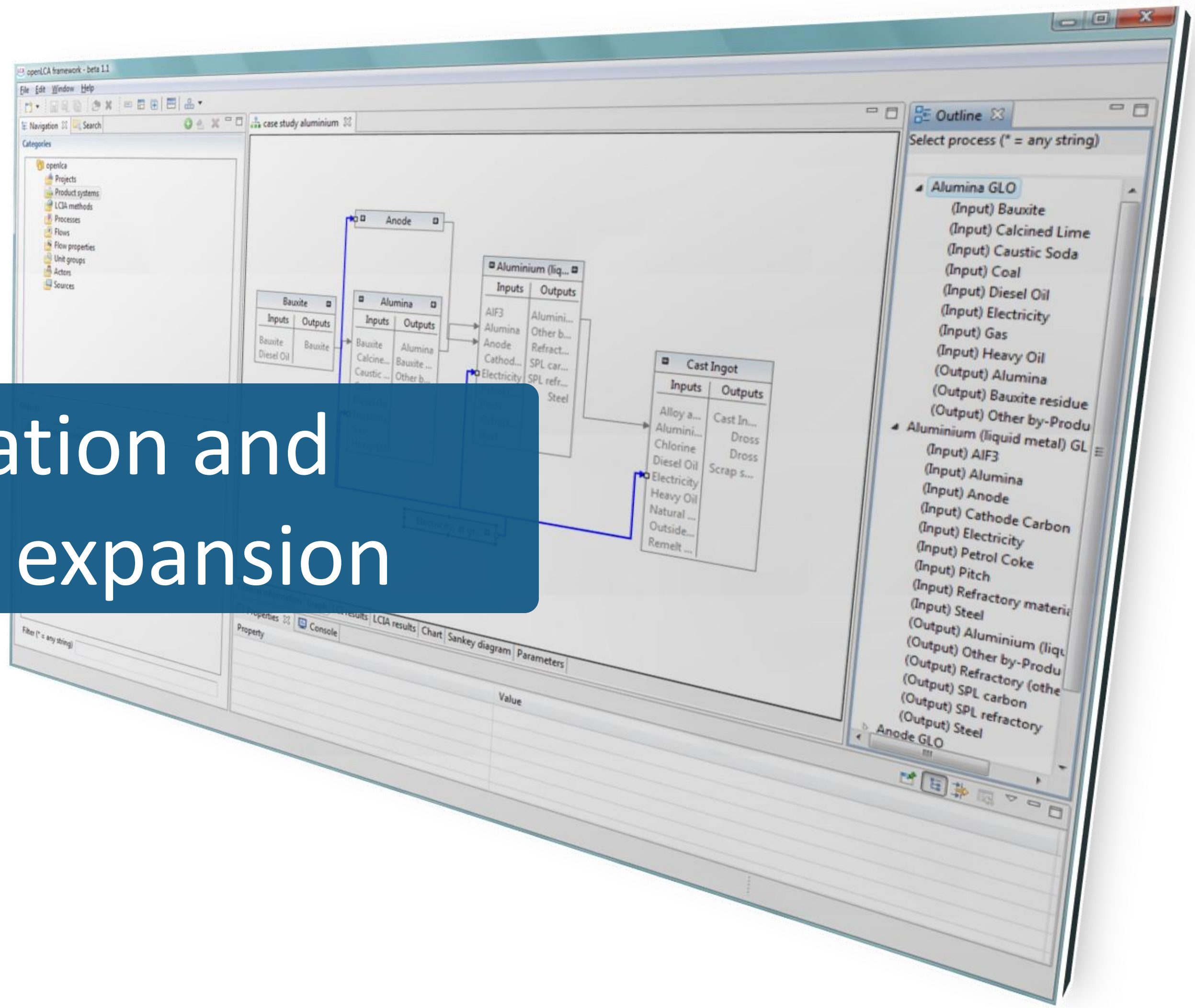
Excercise 6: Modeling
LCA of PET bottles

e) Calculate the product system using the LCIA method “ReciPe Endpoint (H)” and the normalization/ weighting set “Europe ReciPe H/A” (hierarchist perspective; average weighting set)

- What’s the impact of the product system in the endpoint categories “human health”, “ecosystems” and “resource availability”?

- What’s the impact of the product system in the endpoint categories “human health”, “ecosystems” and “resource availability”? How is the ionising radiation impact of PET bottle production in Germany expected to affect “human health”?

- To which endpoint indicator does the product system cause the highest damage after normalization and weighting? Does this result change when an egalitarian or an individual perspective is used (with the average weighting set) instead of a hierarchist view? (resources)



Allocation and system expansion

Multi-output processes

- Multi-output processes occur quite often
  - cow (milk, leather, meat)
  - Co-generation (heat, power)
  - Chloralkali elektrolysis (natriumhydroxide, chloric gas, hydrogen)
- Usually you need processes with one output for LCAs
- Two strategies:
  - Avoiding Allocation: System expansion
  - Elementary flows and products from multi-output processes mathematically divided into multiple processes (= allocation)

Allocation

"partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems"

(ISO 14040)

– Which allocation methods are possible?

- physical allocation
- causal allocation
- economic allocation

Example: co-generation

co-generation

Allocation

Default method: None

Calculate default values

Physical & economic allocation

Product	Physical	Economic
Electricity, at grid, US - RNA (2.00 MJ)	1.0	1.0
Heat, onsite boiler, hardwood mill, average, SE - RNA (1.00 MJ)	1.0	1.0

Causal allocation

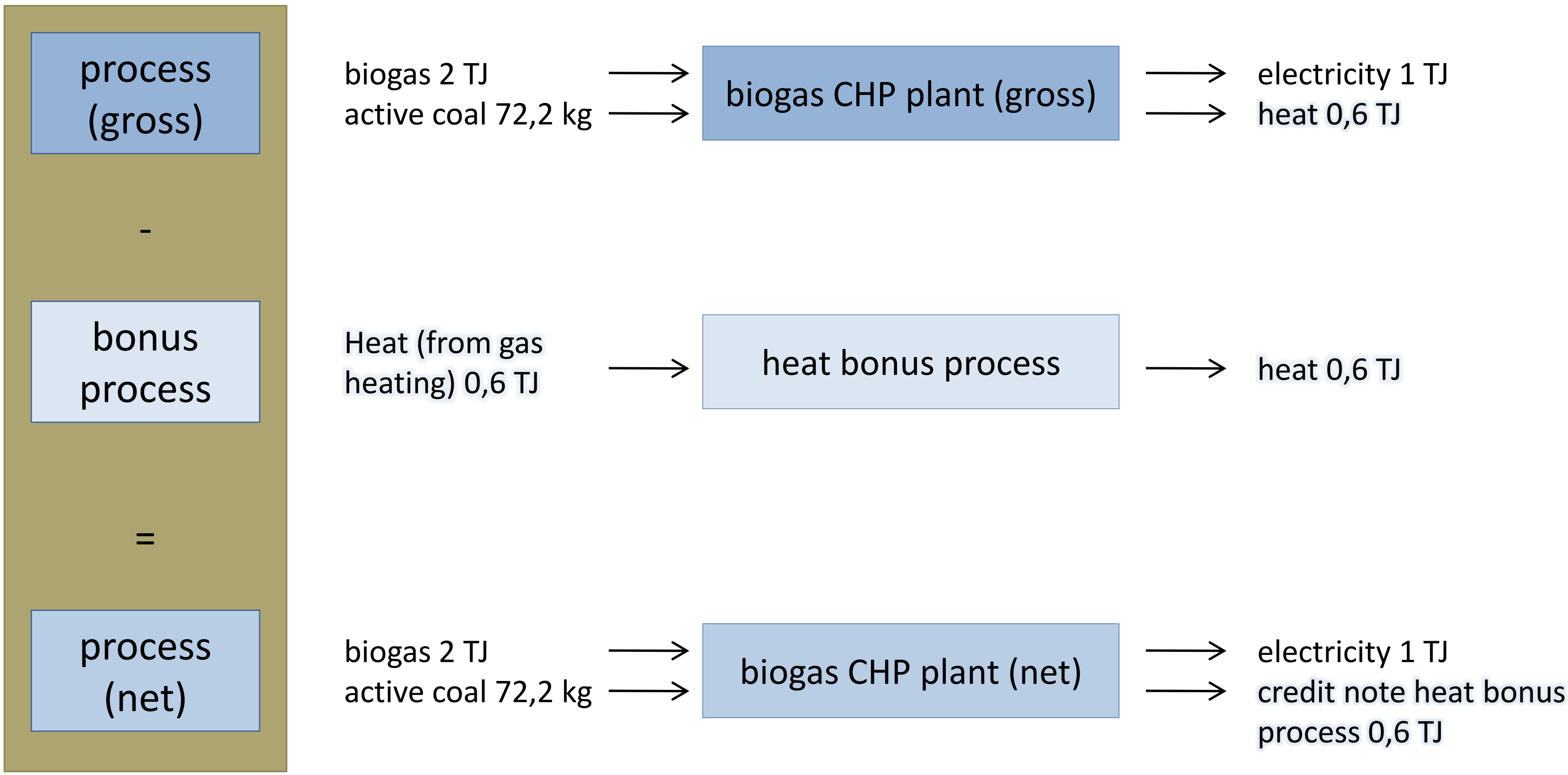
Flow	Direction	Category	Amount	Electricity, at grid, US - RNA	Heat, onsite boiler, hardwood ...
Sulfur dioxide	Output	air/high po...	0.50000 kg	1.0	1.0
Carbon dioxide, fossil	Output	air/high po...	2.00000 kg	1.0	1.0
Crude oil, at production...	Input	Product flo...	3.00000 kg	1.0	1.0

System expansion (I)

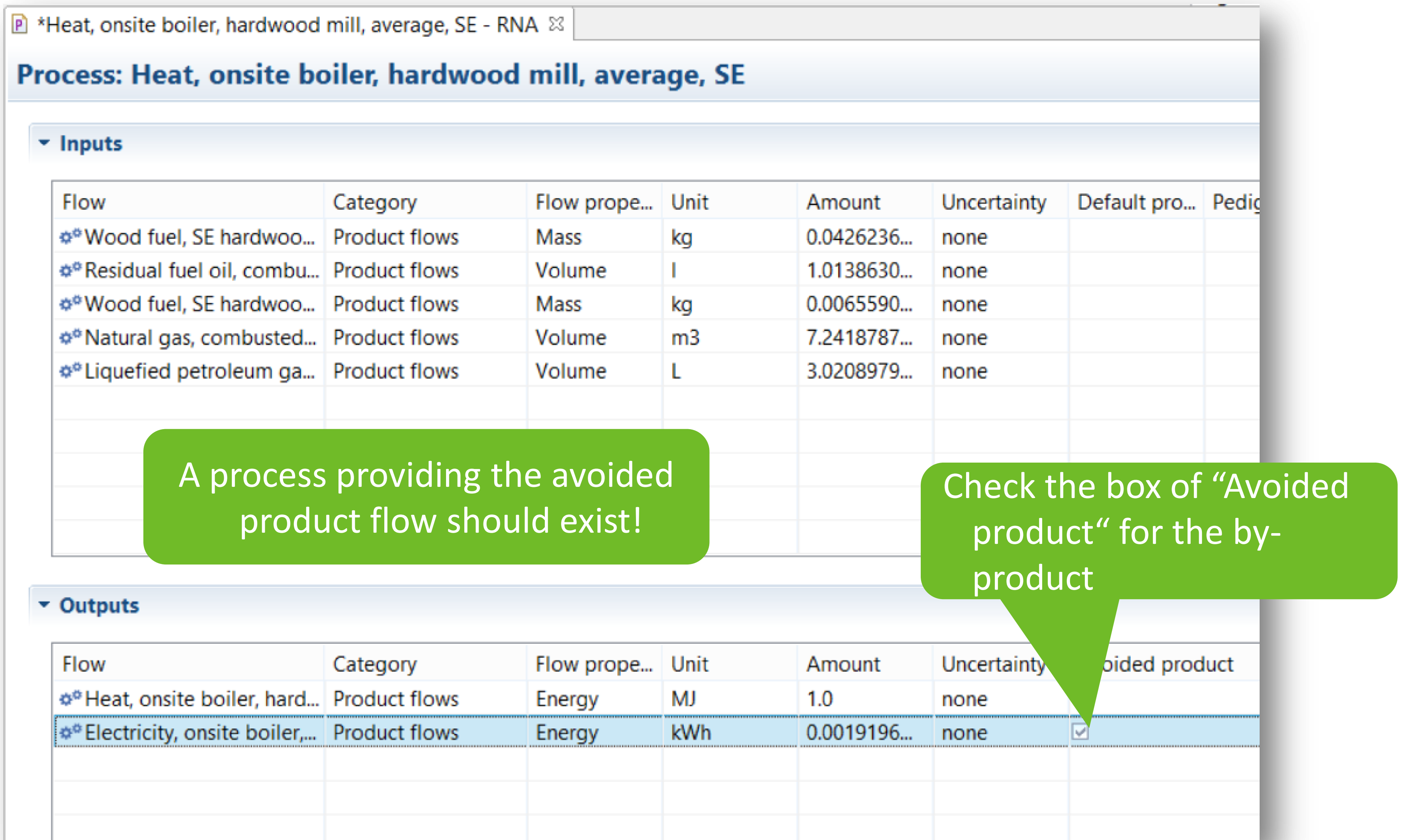
- System expansion --> We assume that heat produced **elsewhere outside** the product system will be **substituted** via the heat produced by our modelled product system.

- The "co-generation" product system is thus "**credited**" with the avoided impacts of the alternative heat-producing process "Heat, gas heating" , i.e. the environmental impacts of the process "Heat, gas heating" will be **subtracted** from the overall environmental impact of co-generation → only impacts related to "electricity" generation" will appear in the LCIA results.

System expansion (II)

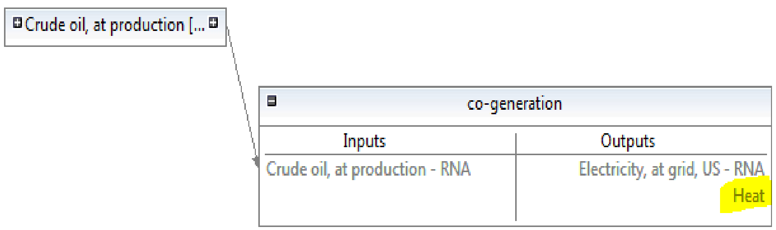


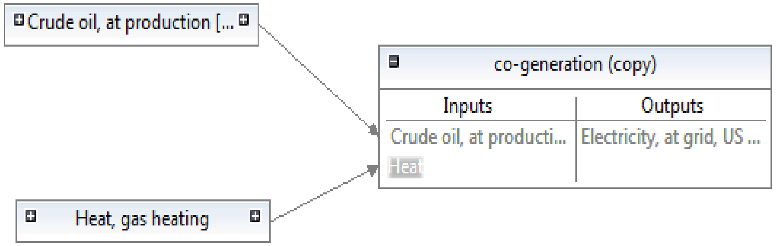
System expansion in openLCA



GreenDelta

System expansion vs. allocation – model graphs



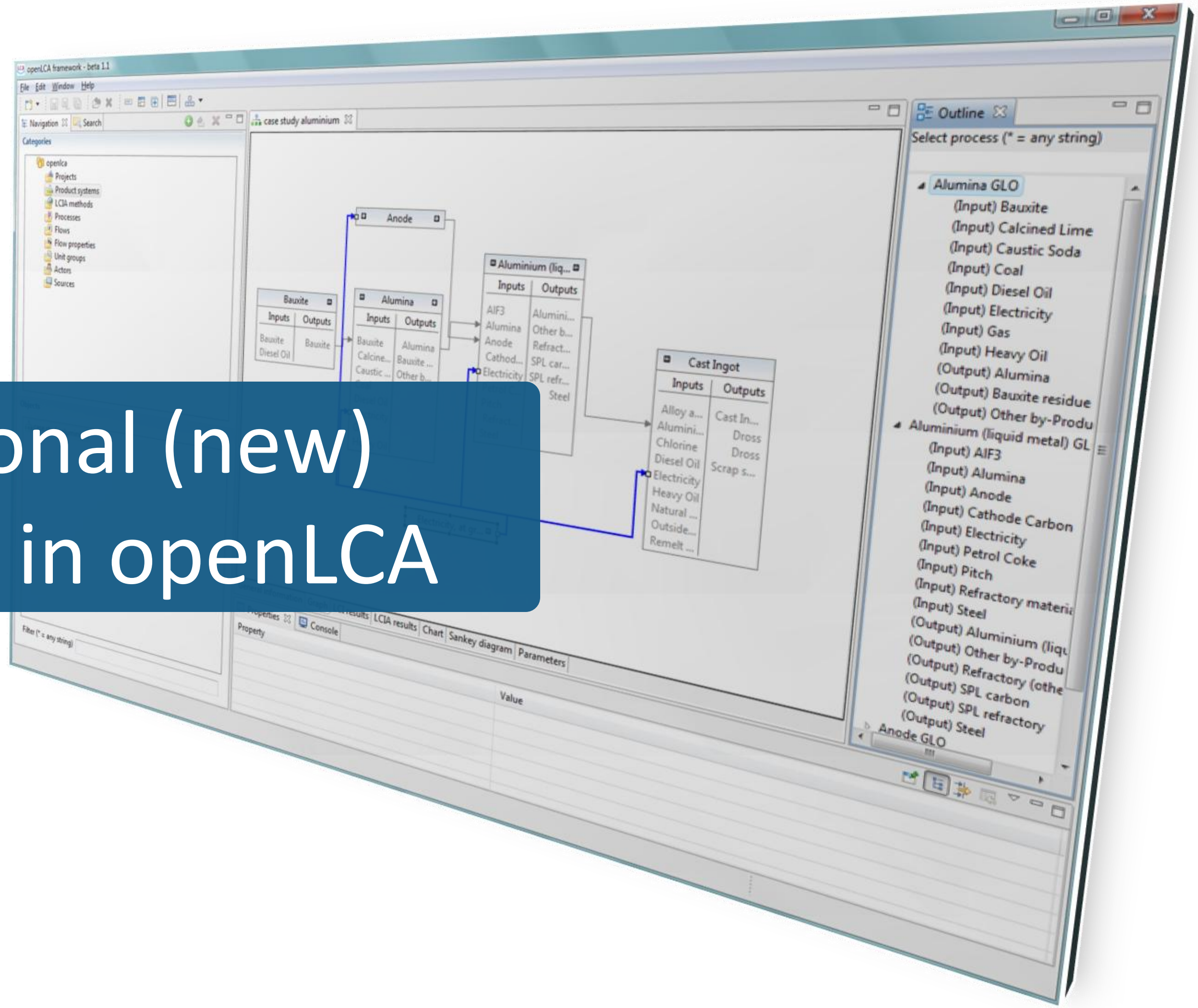


Model Graph 1: Product system "Co-generation" without system expansion

vs.

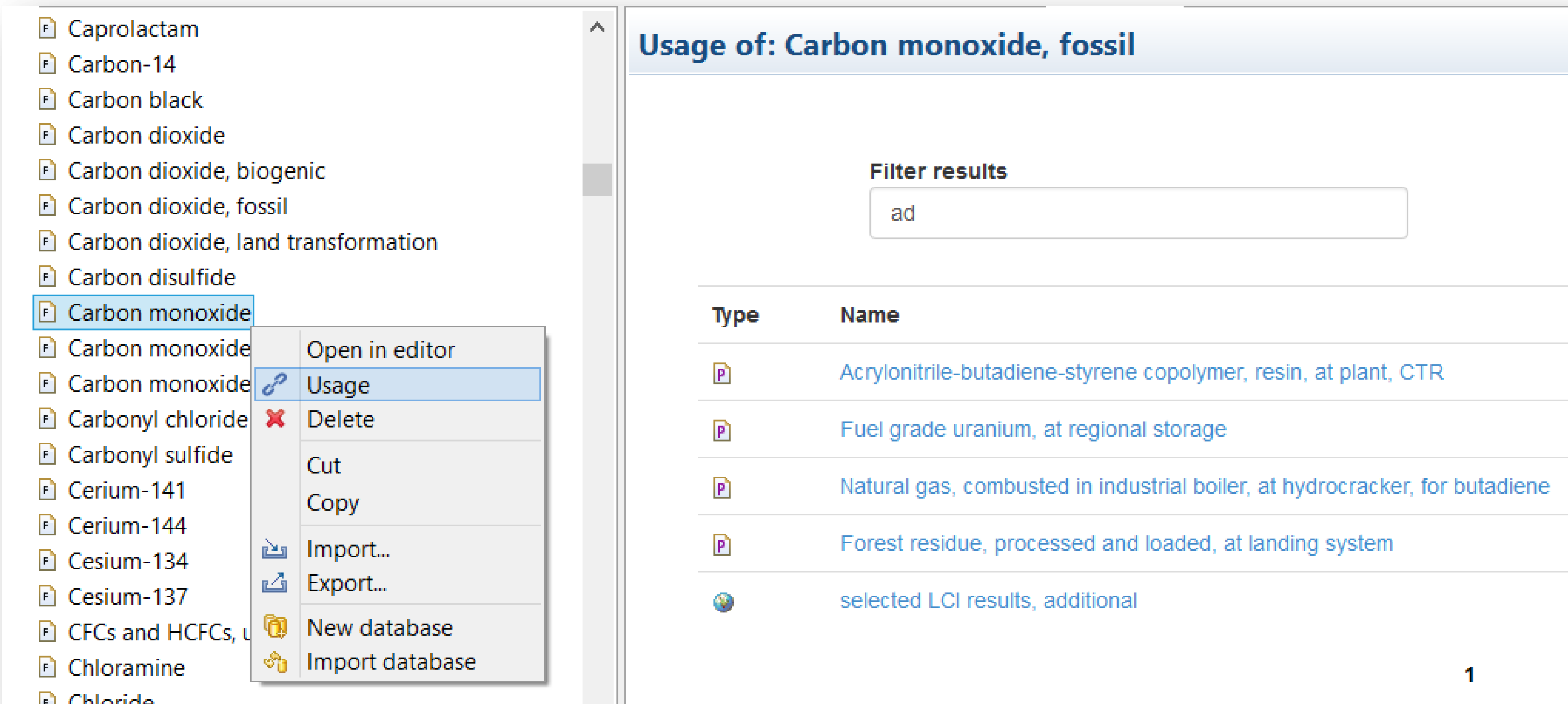
Model Graph 2: Product system "Co-generation " with system expansion

Additional (new) features in openLCA



Element usage

- Available for any element of the database.
- Results can be filtered.



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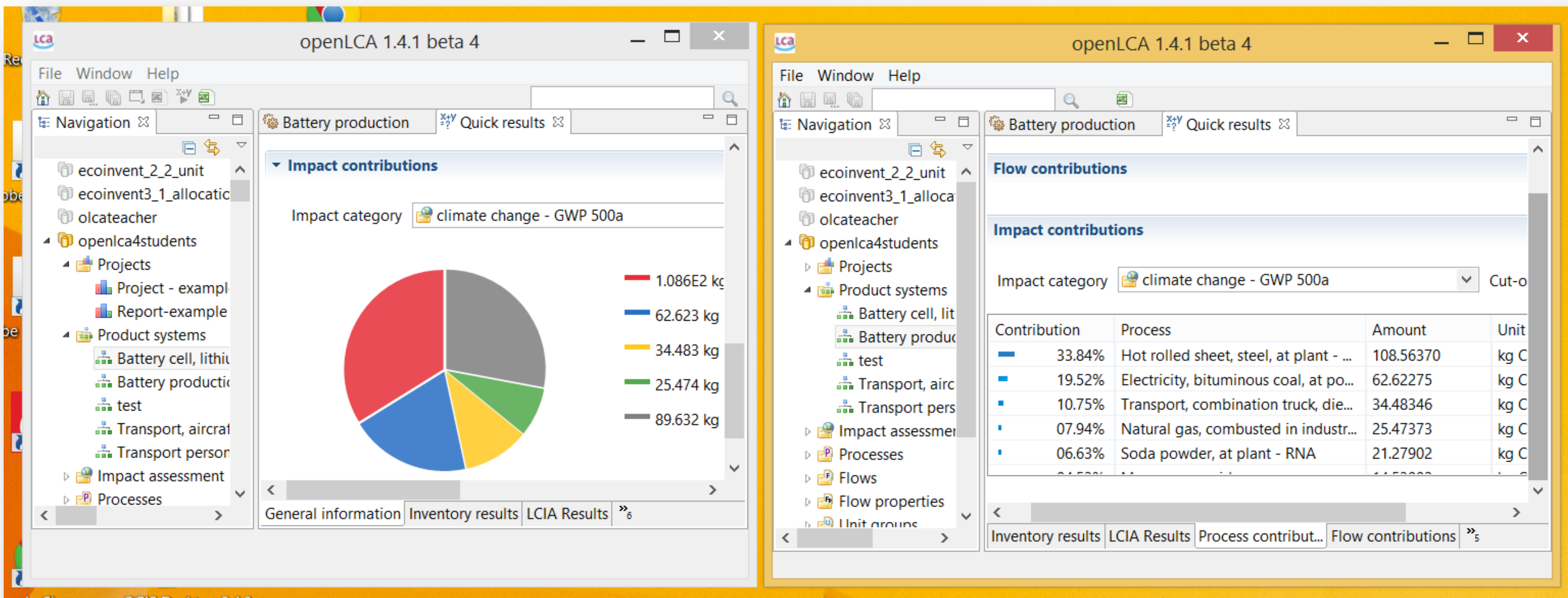
Multiple windows view

- Select Window/Open in New Window to open a new openLCA window
- You can work in parallel within the same database



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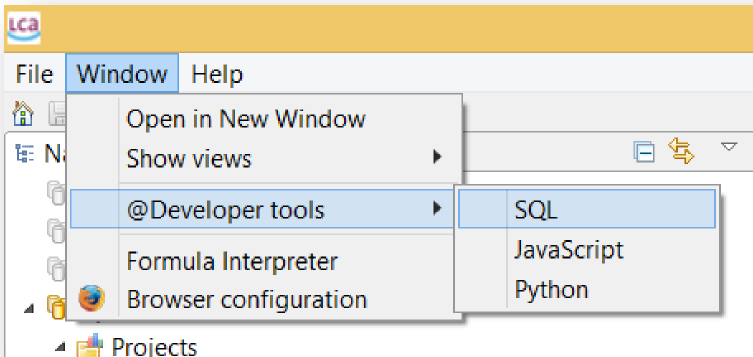
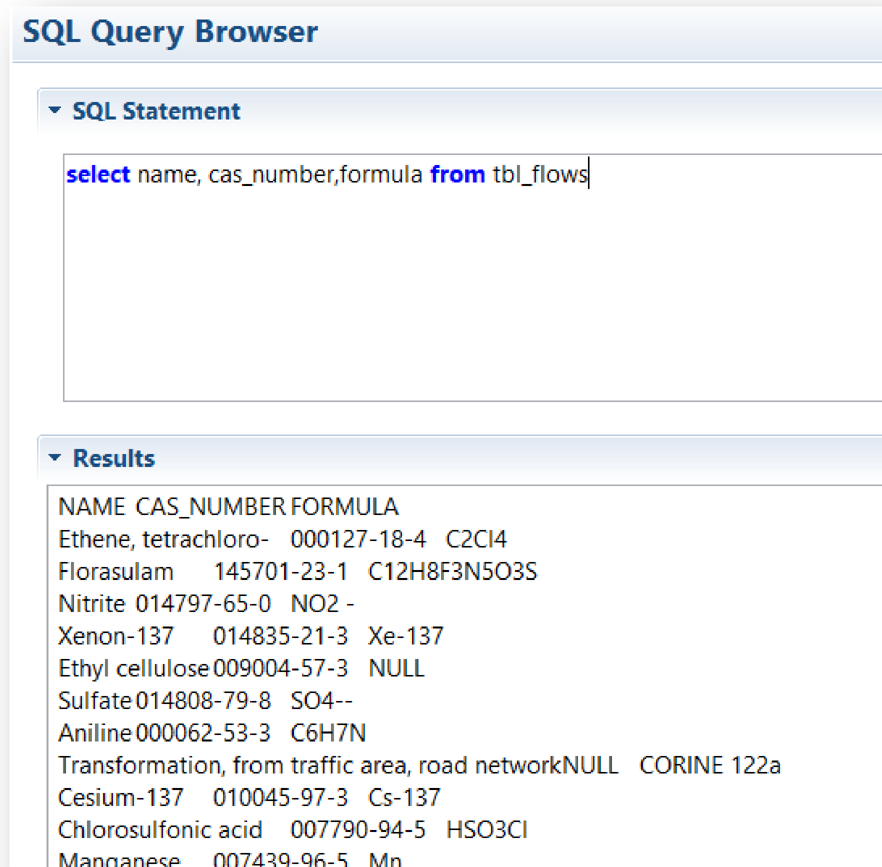
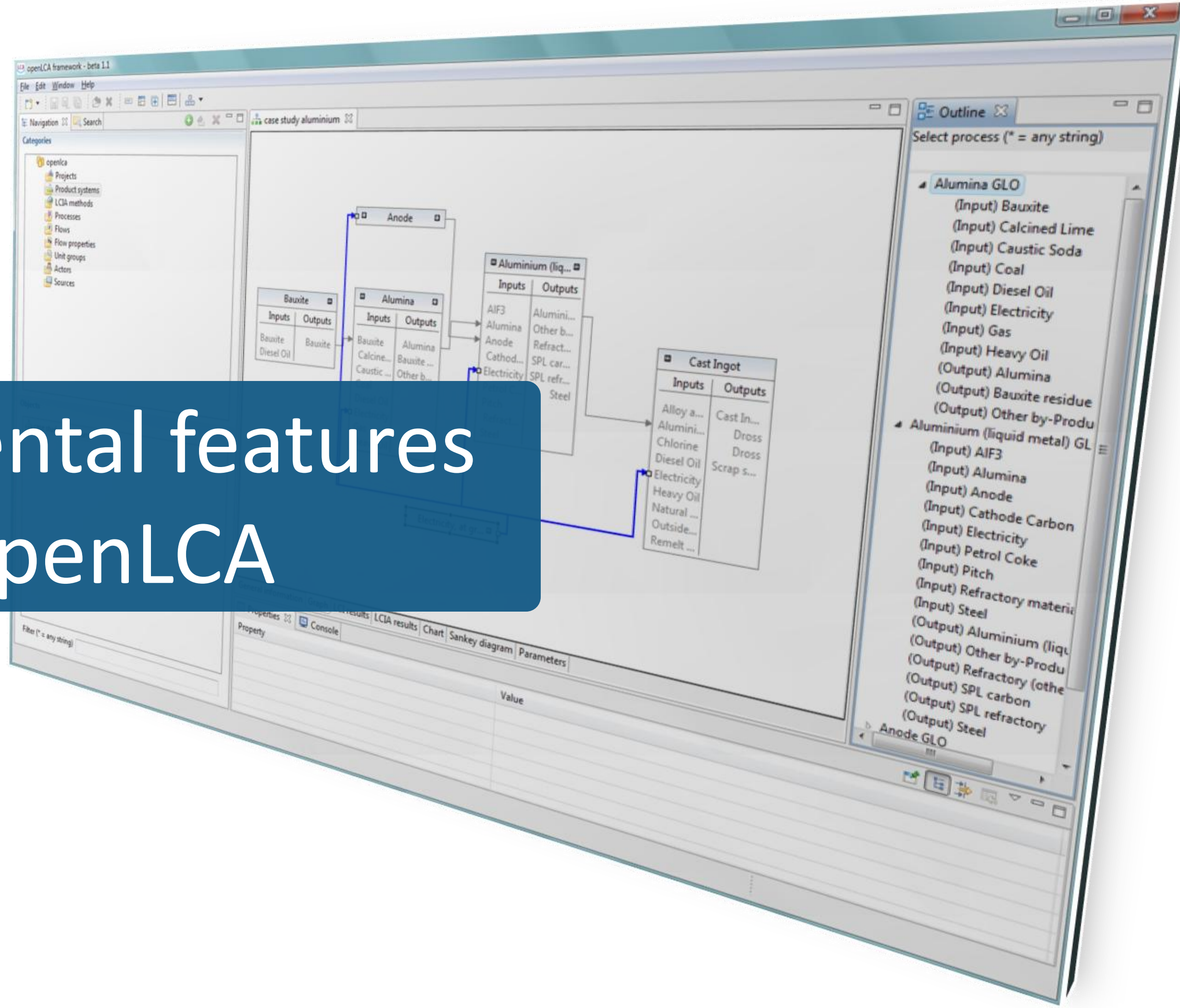
Developer tools

- SQL Query Browser, JavaScript and Python editors.



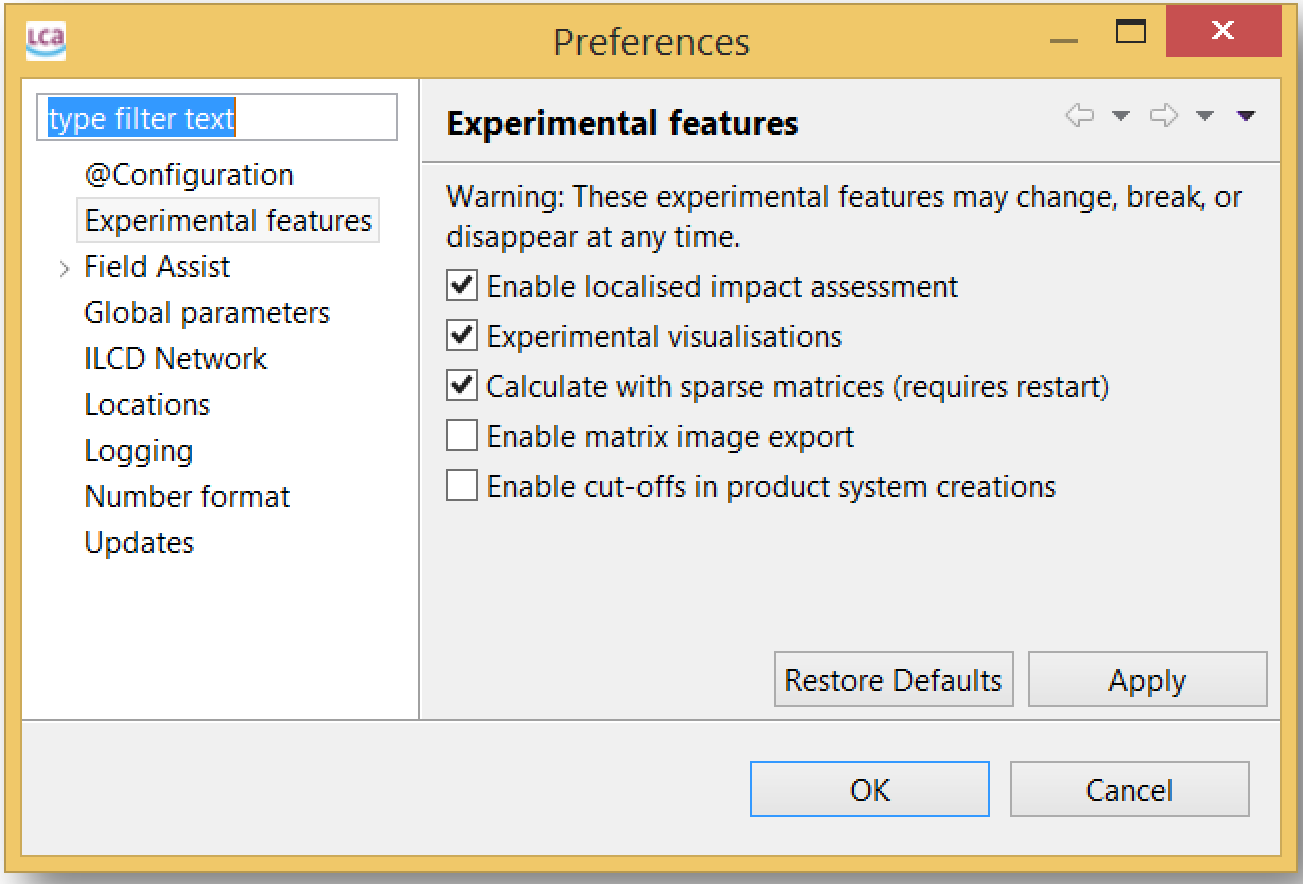


Experimental features in openLCA



Experimental features

They can be activated under File/Preferences/Experimental features



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Product system statistics

- Available in the product system editor
- Provides information on the number of processes, the process links, etc.

Product system statistics

General statistics:

Number of processes	81
Number of process links	230
Connected graph / can calculate?	yes
Technology matrix	81 x 81
Reference process	Battery pack (S1)
	Recalculate

Product system Statistics (II)

Product system statistics

Processes with highest in-degree (linked inputs):

	Number of input links	Process
●	8	Lithium carbonate
●	8	Battery cell, lithium-ion battery (S1)
●	7	Ethylene dichloride-vinyl chloride monomer, at plant
●	7	Electricity, at Grid, US, 2008
●	7	Ethylene, at plant

Processes with highest out-degree (linked outputs)

	Number of output links	Process
●	27	Electricity, at Grid, US, 2008
●	18	Transport, train, diesel powered

General information | Parameters | Model graph | Statistics | HTML Graph

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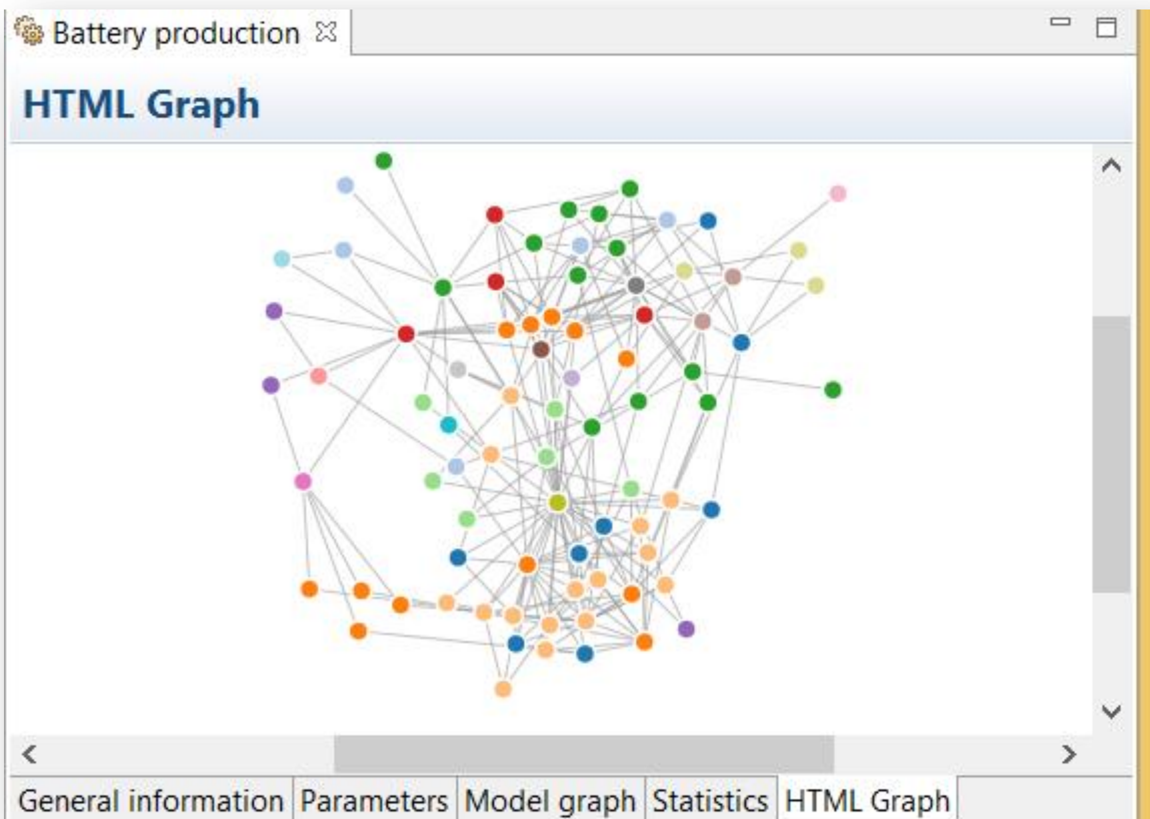
Experimental visualisations: HTML Graph

- Available in the product system editor.
- It provides visual representaion of the process links in the product system.



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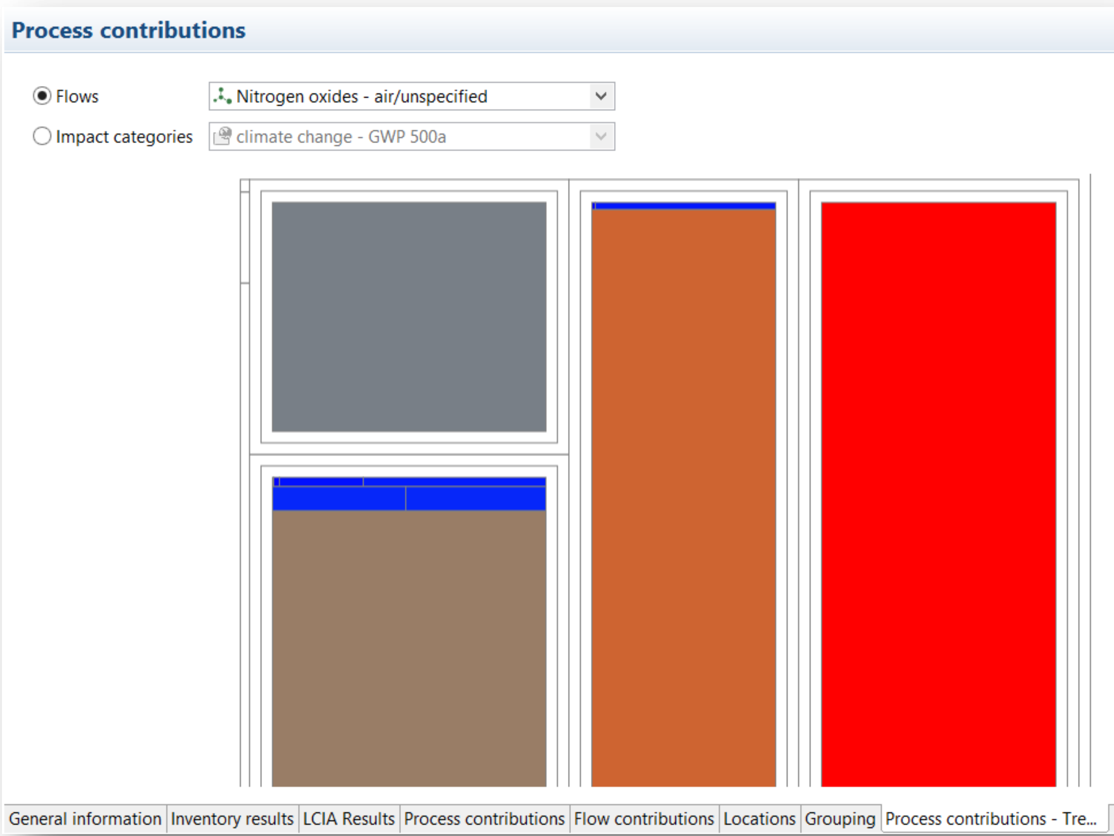
Experimental visualisations: Treemap

- Available in the quick results and anaylsis editors.
- It visually represents the direct process contributions per flow and impact category.



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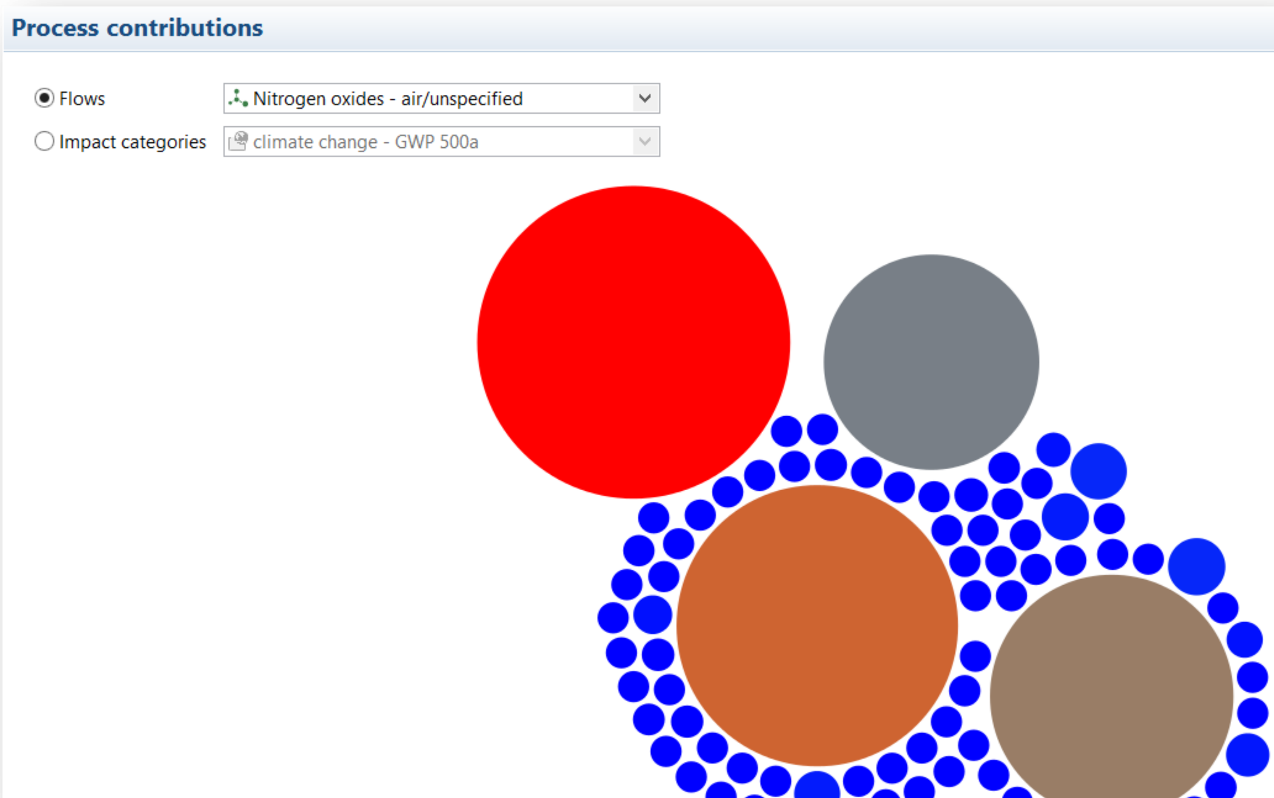
Experimental visualisations: Bubble chart

- Available in the quick results and anaylsis editors.
- It visually represents the direct process contributions per flow and impact category.



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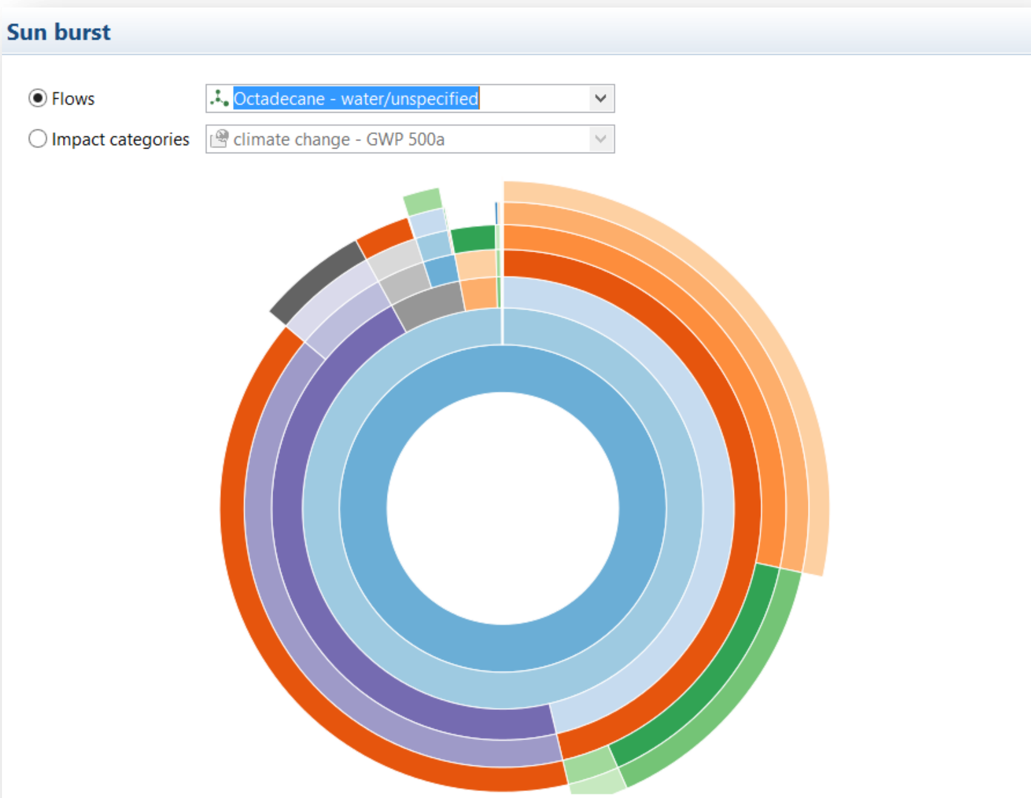
Experimental visualisations: Sun burst

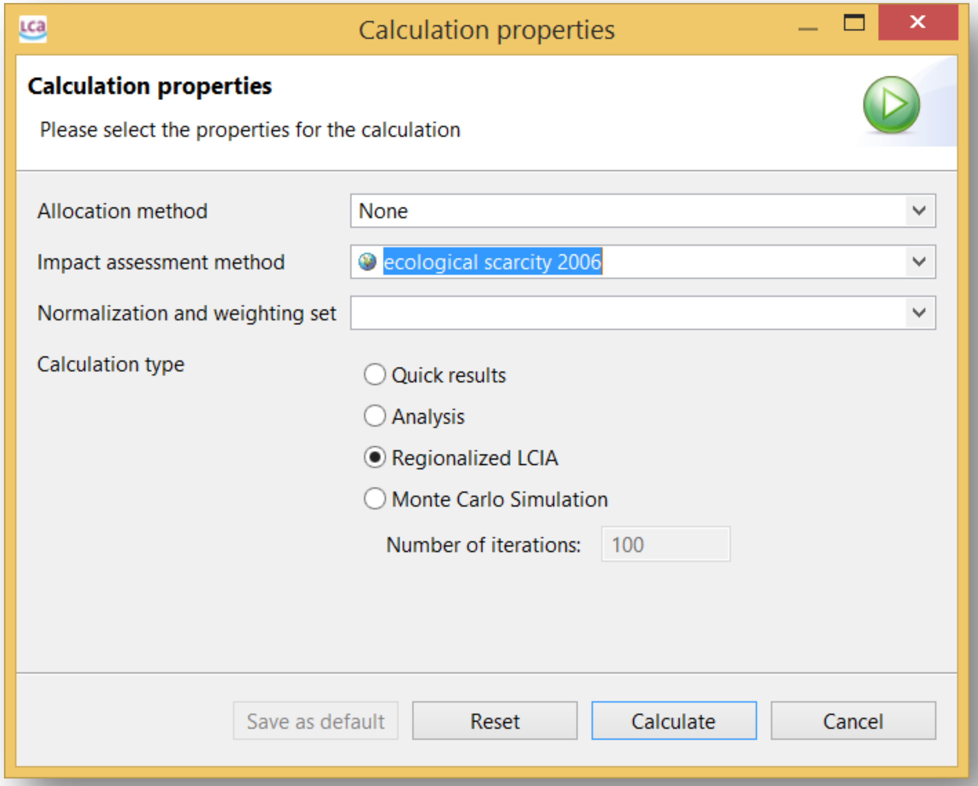
- Available in the anaylsis editor.
- It visually represents the total process contributions per flow and impact category.



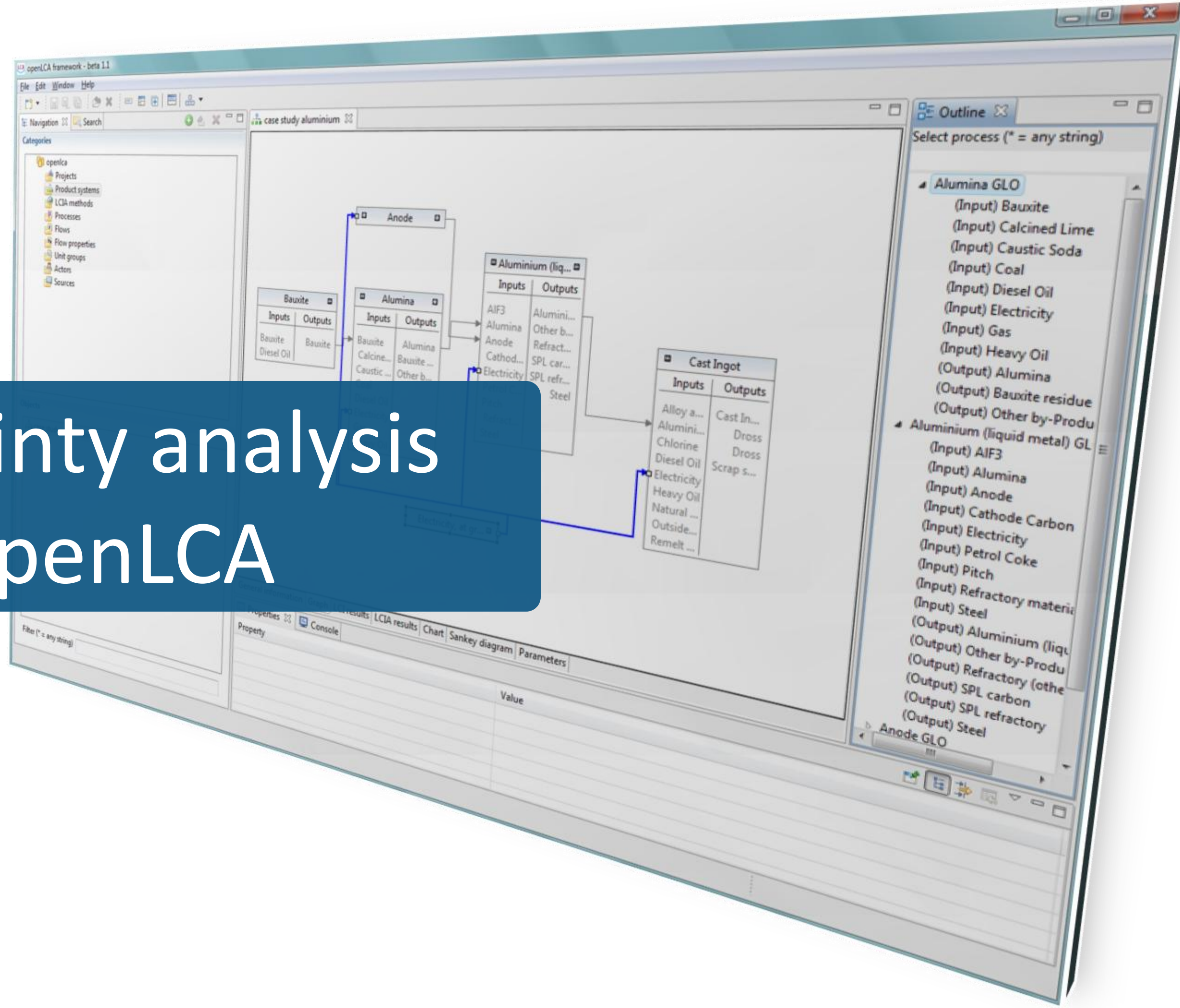
Other experimental features

- Spare matrix calculation: calculates with a different, sparse matrix approach; saves some memory but is still experimental.

- Localised impact assessment:
  - New features in the impact method editor are added to deal with shape files.
  - A new calculation option is shown in the “Calculation properties” menu:



Uncertainty analysis in openLCA



Types of uncertainty

- Data uncertainties
  - Uncertainties through measurements and estimations
  - Uncertainties through the use of non-ideal data sets (region, technology, time period)
  - Uncertainties of consumer behaviour regarding use and disposal of products
  - ...
- Uncertainties in LCIAM due to lack of scientific knowledge
- ...

Data uncertainty: basics I

- It is basically not possible to measure error-free.

- But: Data uncertainty is in contrast to other uncertainties quite easy to handle with statistical methods (e.g. Monte Carlo simulation, Pedigree approach, interval calculations, with fuzzy logic approach or the Gaussian error propagation formulas)

→ Measurements have a distribution; the scope is defined as standard deviation.

Data uncertainty: basics II

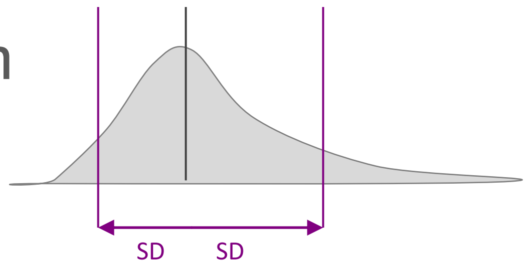
→ Results have also a standard deviation and a mean as well as an average:

- The median is the mean value (for 100 samples the 50th sample is the median).

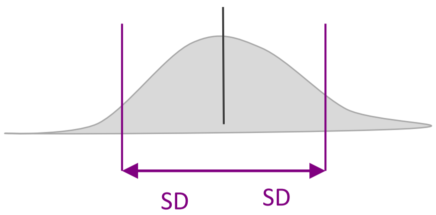
- The mean is the arithmetic average of all samples.

Uncertainty distribution

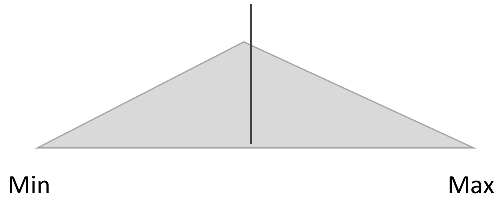
- Log-normal distribution



- Normal distribution



- Triangle distribution



- Uniform distribution

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The Monte Carlo simulation (I)

- Simulation varies entry data of the model calculation randomly according to the uncertainty distribution.

- An uncertainty distribution for the calculation result is provided.

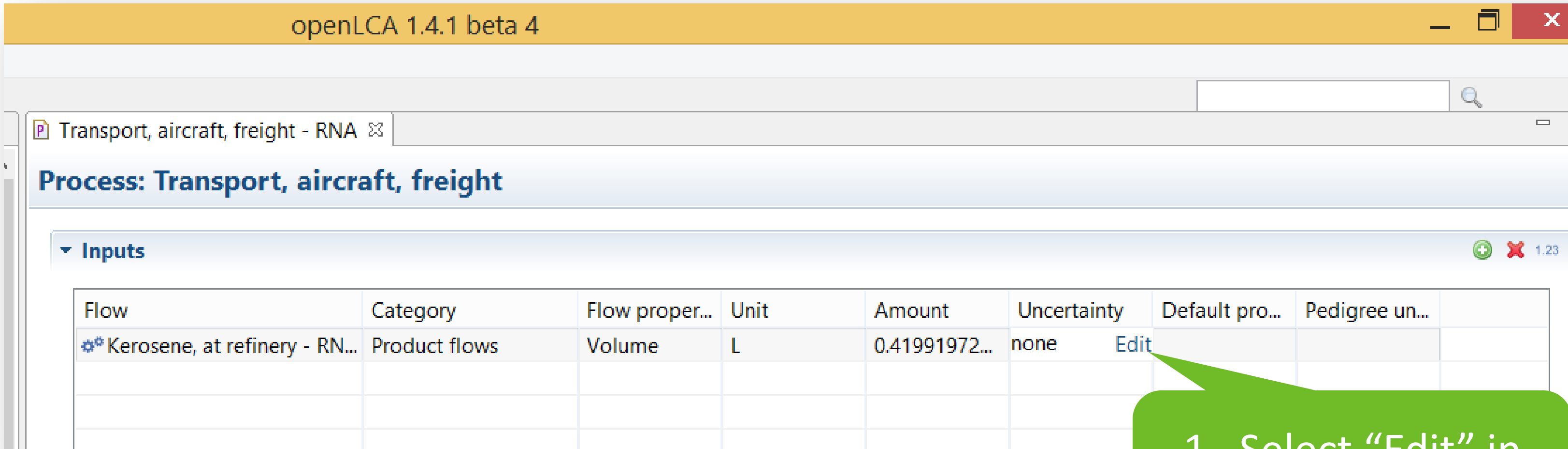
- By a breakdown of the value ranges in individual intervals and the alternate drawing from different intervals, a more uniform distribution of the results is achieved, thereby reducing the number of iterations required.

- Nevertheless, several thousand iteration passes are usually required.

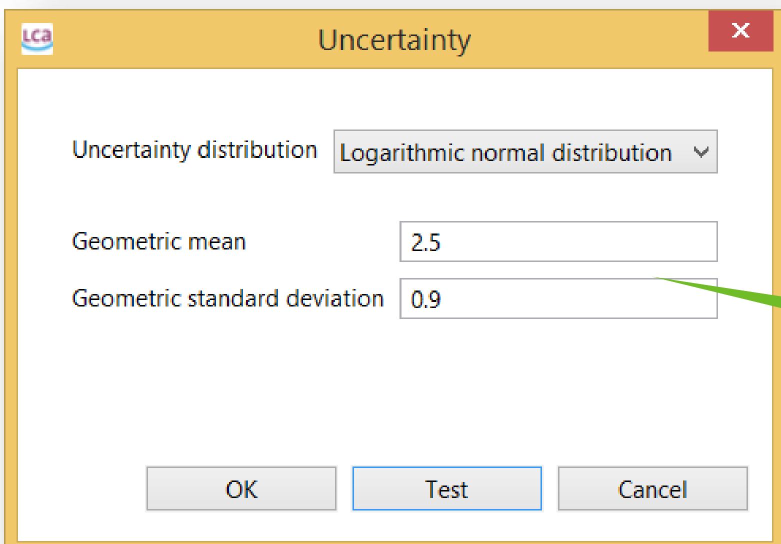
The Monte Carlo simulation (II)

- First, uncertainty data are added to all flows in the processes (Distribution, standard deviation, min / max, etc.); only for the reference output no uncertainty distribution is assumed.
  - Uncertainty data can be defined also for parameters and LCIA characterisation factors
- Then, in the calculation window the Monte Carlo simulation can be selected and the number of simulations can be entered.
- Uncertainties are calculated for each flow or impact category.

Adding uncertainty information

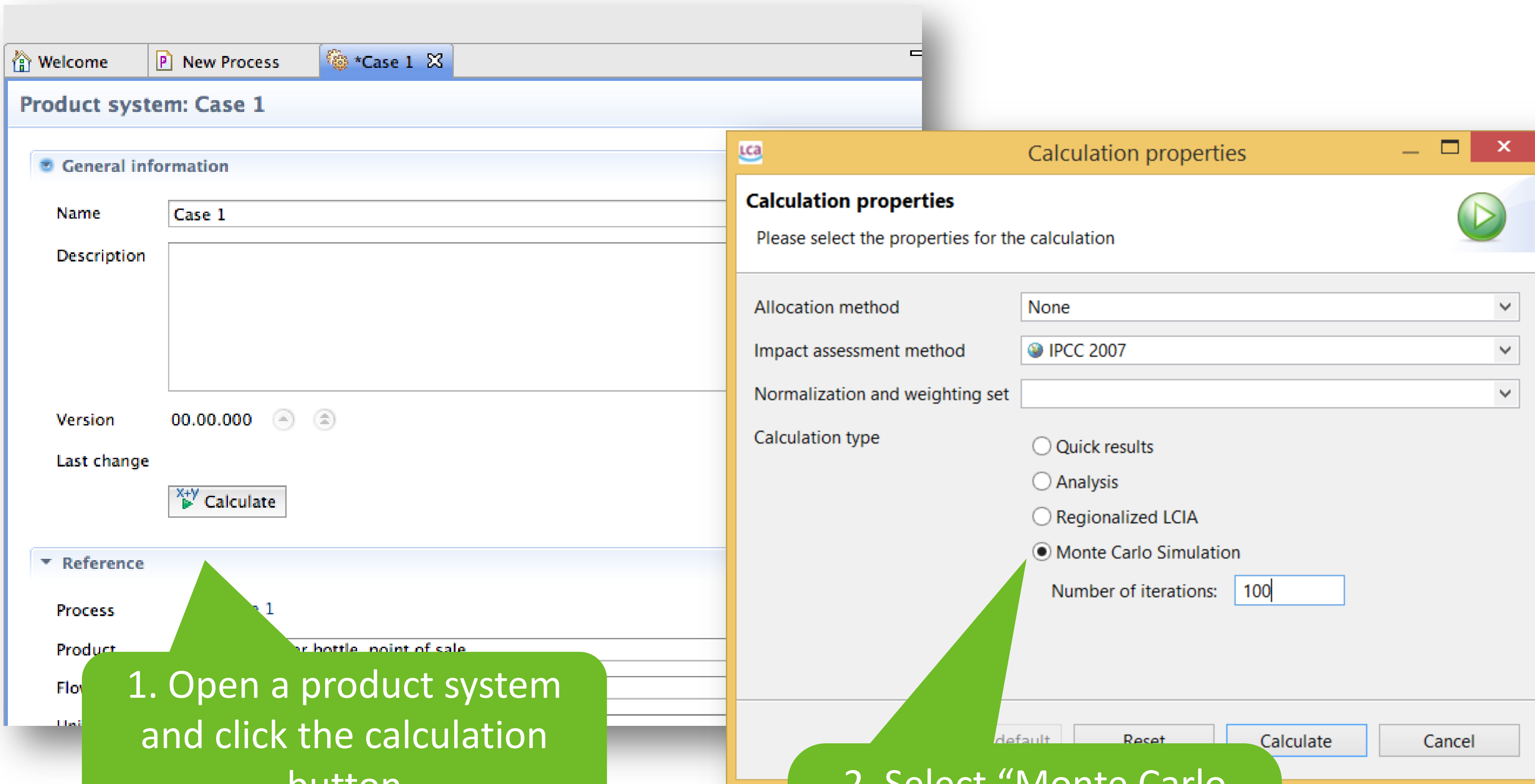


1. Select "Edit" in the uncertainty field



2. Define the values of the distribution

Starting the Monte Carlo simulation



1. Open a product system and click the calculation button

2. Select "Monte Carlo "Simulation", the impact method and the number of iterations

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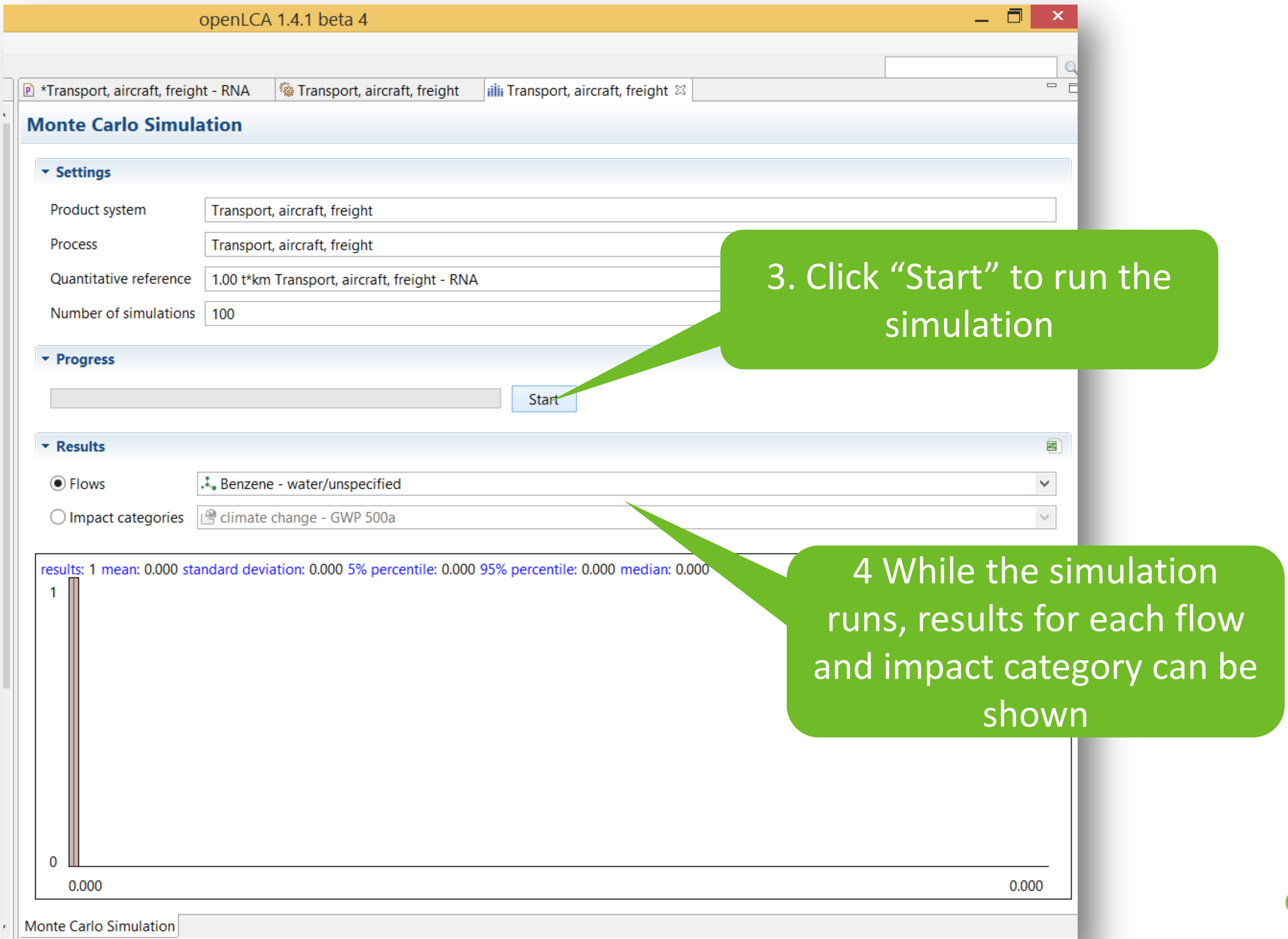
Starting the Monte Carlo simulation



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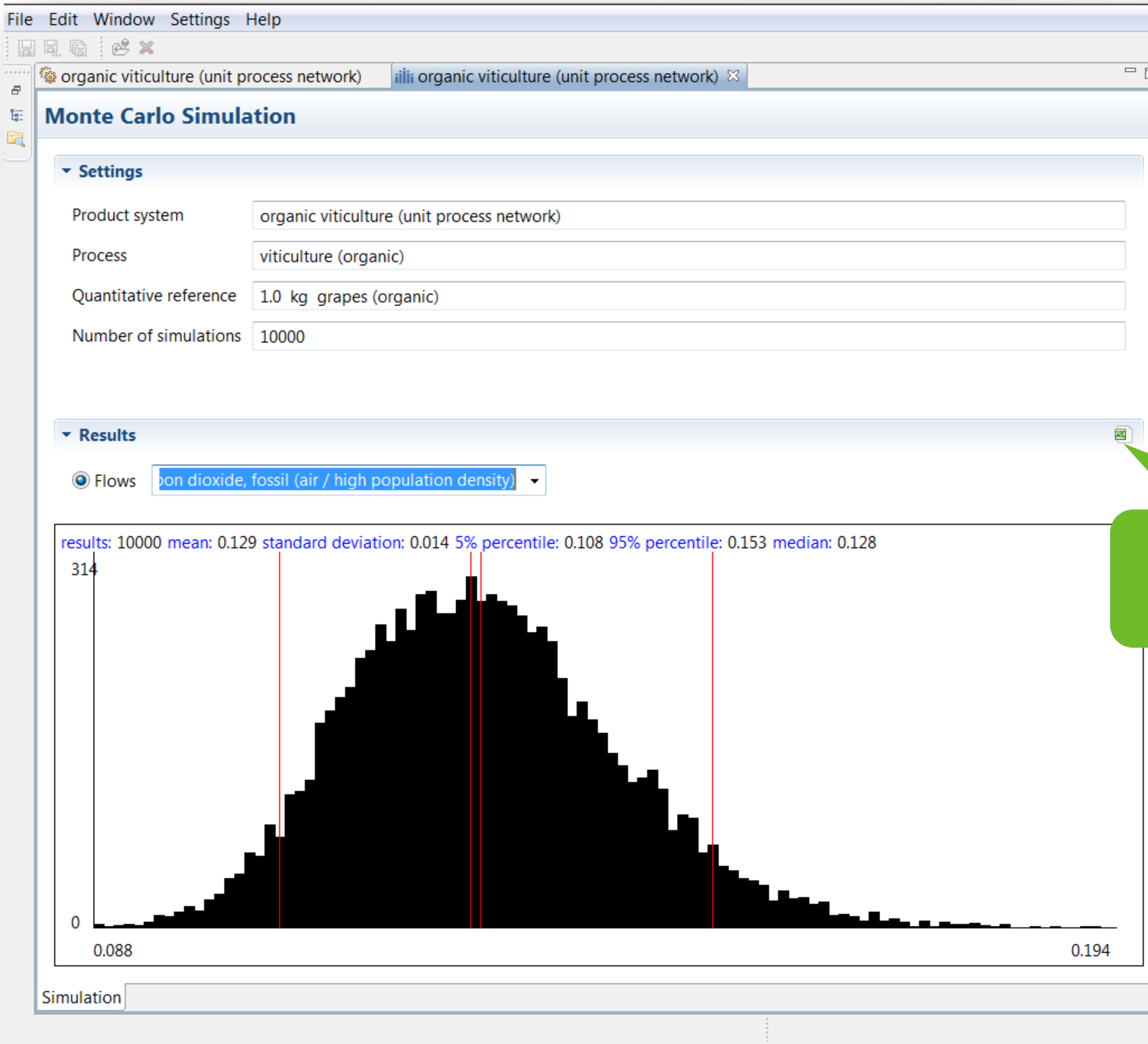
Results



5 Results can be exported as Excel

The Pedigree approach in ecoinvent

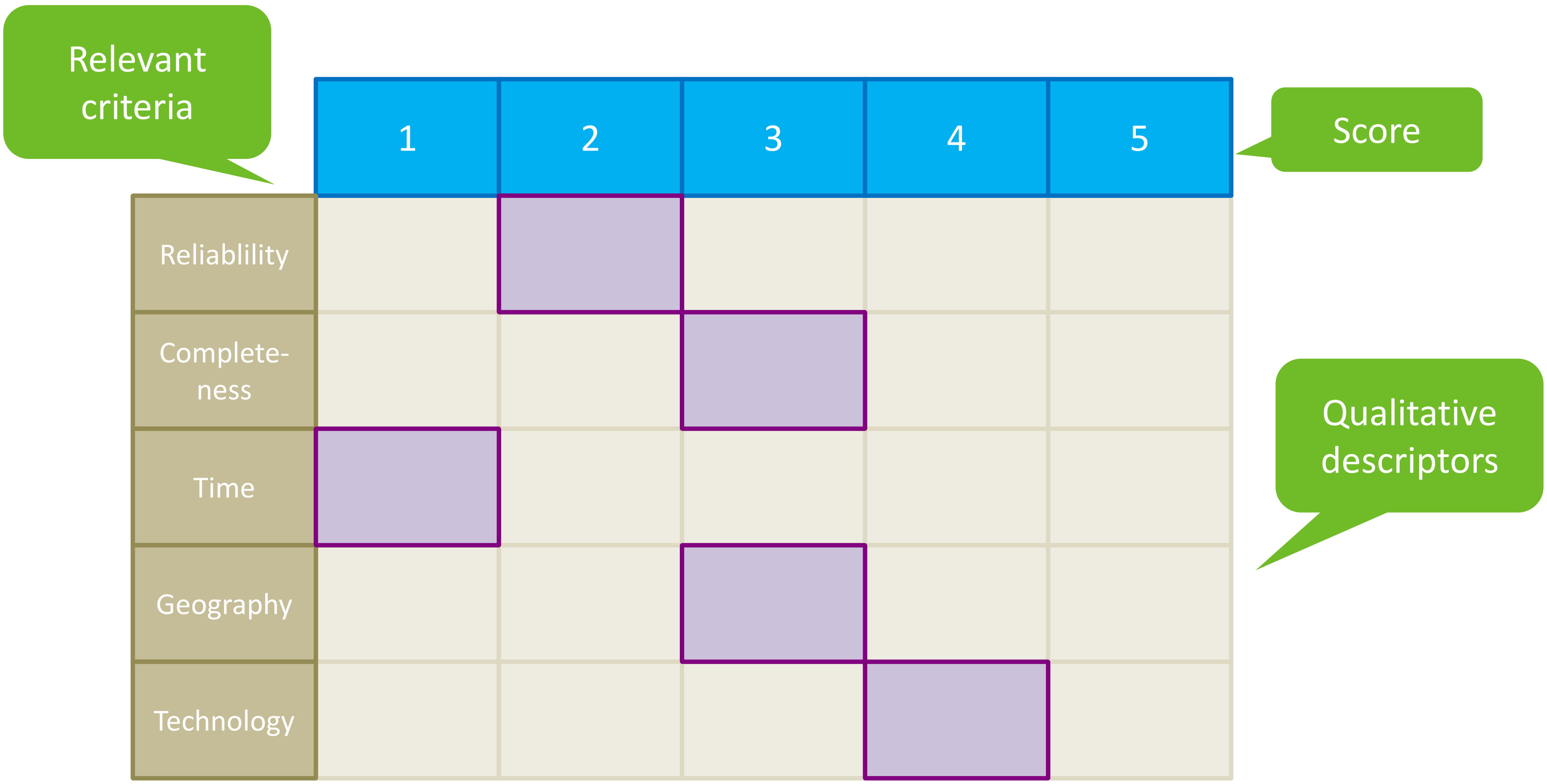
- Developed by Weidema and Wesnaes in 1996 as part of their NUSAP scheme to estimate all kinds of uncertainty

- A pedigree illustrates key aspects in a matrix:
  - Columns represent pedigree criteria
  - Lines represent qualitative characterisations of each criteria by expressing different levels of data quality or uncertainty

- Quantitative scores are assigned to each qualitative description

- The pedigree matrix was transferred in 1996 by Weidema / Wesnaes on the application in LCA.

The Pedigree approach in ecoinvent



The Pedigree approach in ecoinvent

	1	2	3	4	5
Reliability	1.00	1.05	1.10	1.20	1.50
Complete-ness	1.00	1.02	1.05	1.10	1.20
Time	1.00	1.03	1.2	1.20	1.50
Geography	1.00	1.01			1.10
Technology	1.00		1.50	1.50	2.00

Default uncertainty factors

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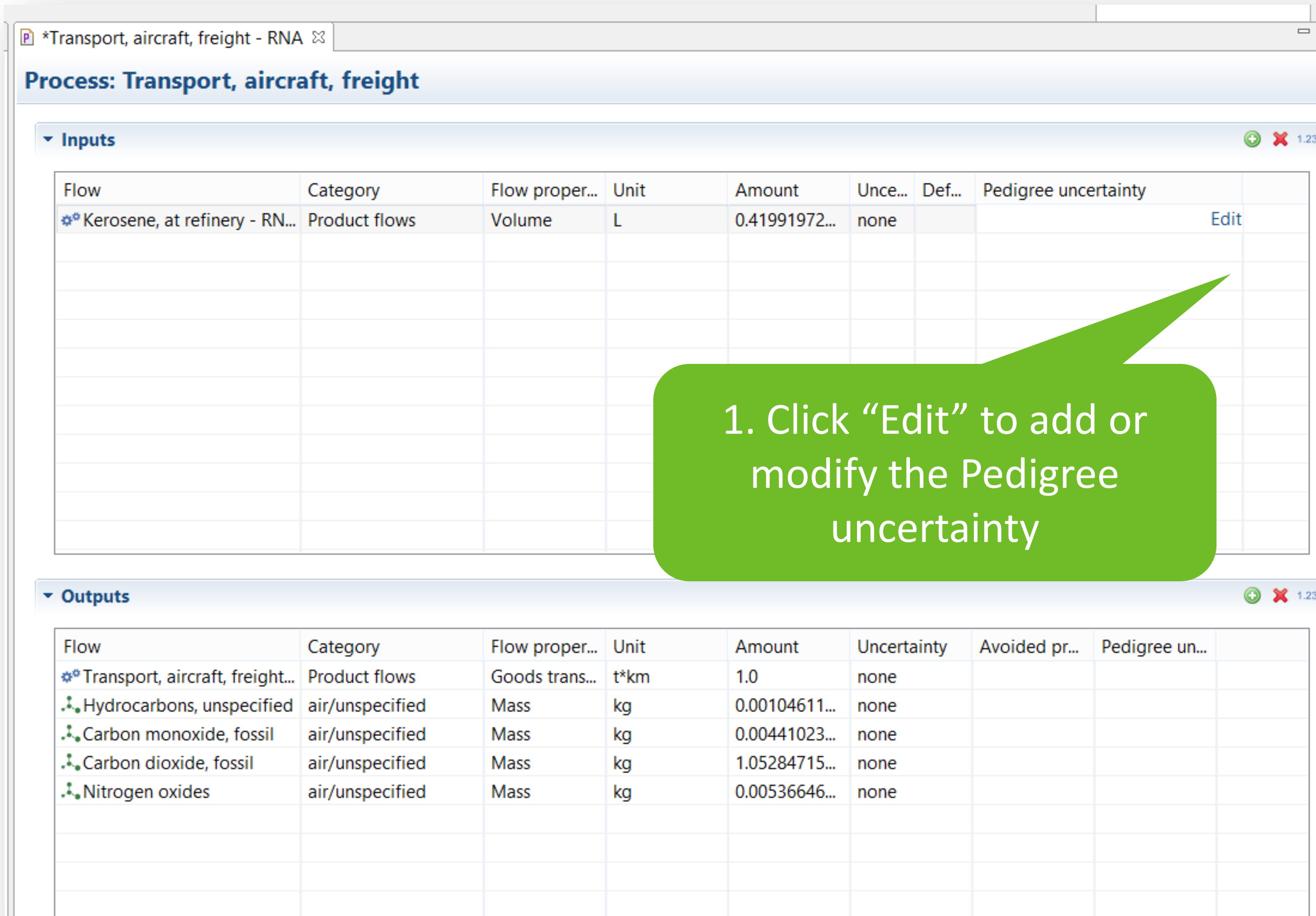
The Pedigree matrix in openLCA


*Transport, aircraft, freight - RNA

Process: Transport, aircraft, freight

Inputs

Flow	Category	Flow proper...	Unit	Amount	Unce...	Def...	Pedigree uncertainty
Kerosene, at refinery - RN...	Product flows	Volume	L	0.41991972...	none		Edit

Outputs

Flow	Category	Flow proper...	Unit	Amount	Uncertainty	Avoided pr...	Pedigree un...
Transport, aircraft, freight...	Product flows	Goods trans...	t*km	1.0	none		
Hydrocarbons, unspecified	air/unspecified	Mass	kg	0.00104611...	none		
Carbon monoxide, fossil	air/unspecified	Mass	kg	0.00441023...	none		
Carbon dioxide, fossil	air/unspecified	Mass	kg	1.05284715...	none		
Nitrogen oxides	air/unspecified	Mass	kg	0.00536646...	none		

The Pedigree matrix in openLCA

Pedigree matrix

Click on the matrix cells to select entries

Indicator score	1	2	3	4	5
Reliability	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on qualified estimates	Qualified estimate (e.g. by industrial expert)	Non-qualified estimates
Completeness	Representative data from all sites relevant for the market considered, over and adequate period to even out normal fluctuations	Representative data from > 50% of the sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from only some sites (<< 50%) relevant for the market considered or > 50% of sites but from shorter periods	Representative data from only one site relevant for the market considered or some sites but from shorter periods	Representativenes s unknown or data from a small number of sites and from shorter periods
Temporal correlation	Less than 3 years of difference to the time period of the data set	Less than 6 years of difference to the time period of the data set	Less than 10 years of difference to the time period of the data set	Less than 15 years of difference to the time period of the data set	Age of data unknown or more than 15 years of difference to the time period of the data set
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown or distinctly different area (North America instead of Middle East, OECD-Europe instead of Russia)
Further technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study (i.e. identical technology) but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials	Data on related processes on laboratory scale or from different technology

Base uncertainty: 1.0 σg: 1.2555818742947564 OK Cancel

2. Click in the different fields to rate the data quality, add a basic uncertainty and click „OK“

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Basic uncertainty

- Developed by the ecoinvent centre:

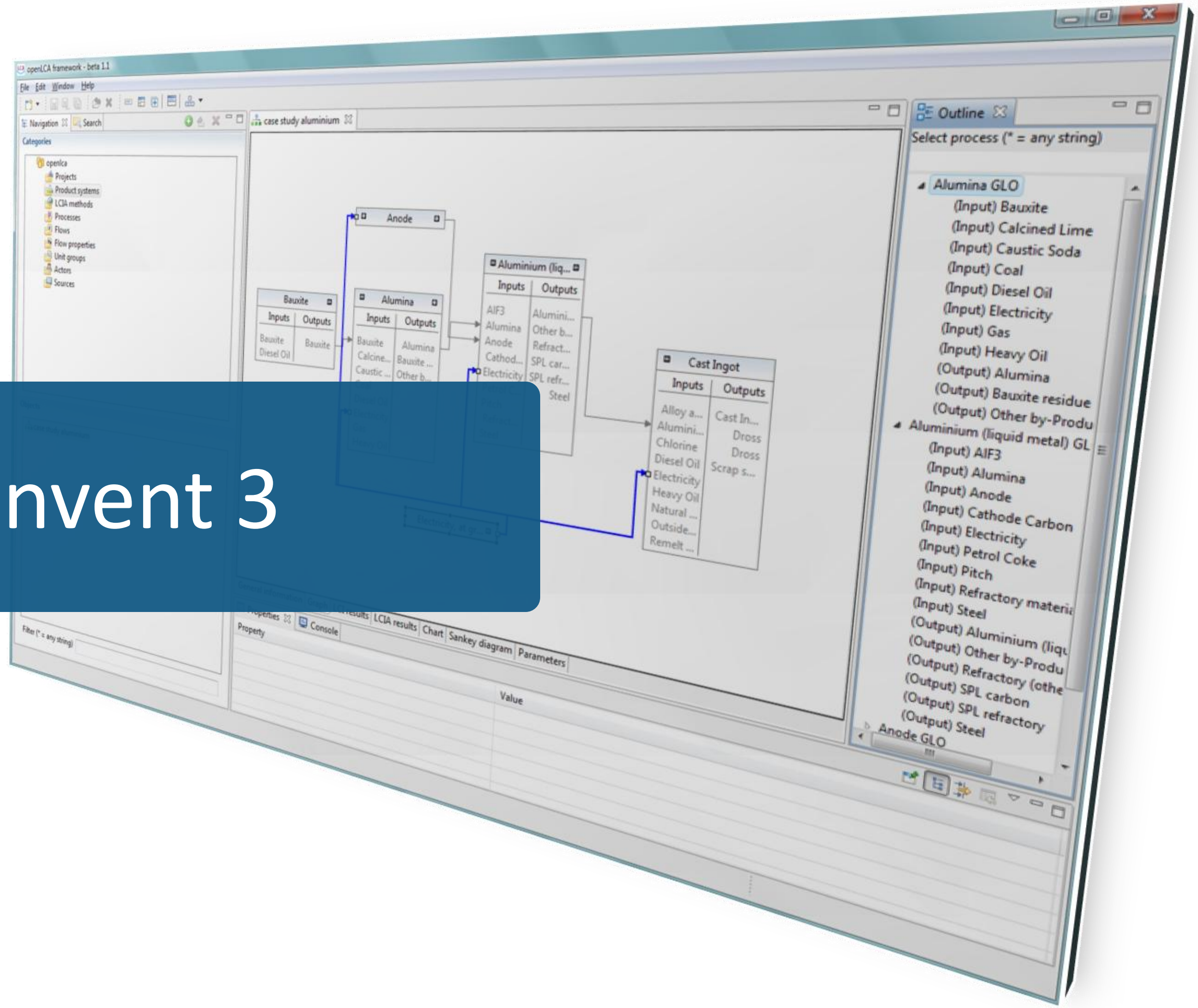
Basic uncertainty	Value
Energy requirement	1.05
Transportation services	2.00
Infrastrukture	3.00
CO2 in air	1.05
PM2.5 of combustion	3.00
Heavy metal in water	5.00
Radionuclides in water	3.00

Calculation of Pedigree uncertainty

- So far the pedigree matrix is only used for documentation purposes!

- In later openLCA versions the pedigree values will be used to determine all uncertainty parameters to run a Monte Carlo simulation (Distribution, standard deviation, min / max, etc.)

- Derived uncertainties can then be calculated using the Monte Carlo simulation.


Outline
Select process (* = any string)
Alumina GLO
(Input) Bauxite
(Input) Calcined Lime
(Input) Caustic Soda
(Input) Coal
(Input) Diesel Oil
(Input) Electricity
(Input) Gas
(Input) Heavy Oil
(Output) Alumina
(Output) Bauxite residue
Anode
Bauxite
Alumina
Cast Ingot
Inputs
Outputs

ecoinvent 3

Ecoinvent 3 Overview

- Third version of the ecoinvent database, developed by the Swiss ecoinvent Centre, with technical modifications respect to version 2:
  - Data format
  - Market modeling
  - Around 8000 "Activity" data sets (former process data sets)

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Ecoinvent 3, Details

- Data format
- Market modeling
- New data?
- Consequences for openLCA

Ecoinvent 3, Data format

- In ecoinvent 2, Ecopsold 1:
  - No parameters,
  - Only two languages,
  - Usually process=product
  - No IDs, processes were identfied by location, time, unit and name
  - It only had processes and metadata
  - Each flow had only one unit
- Ecospold 2;
  - Parameters
  - Different data sets (Activity, flow, etc.)
  - Unique Ids
  - "Intelligence" in data format

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EcoSpold 2


```xml
<?xml version="1.0" encoding="utf-8"?>
<ecoSpold xmlns="http://www.EcoInvent.org/EcoSpold02">
  <childActivityDataset>
    <activityDescription>
      <activity id="0a5c6801-e080-4b4e-b029-b80b73a54fd7" activityNameId="11916431-4240-4fb7-b7a2-90f90e35c400" parentActivityId="d63fcb68-86ed-4554-ab3c-b4ba5c7b0
        <activityName xml:lang="en">titanium zinc plate production, without pre-weathering</activityName>
        <includedActivitiesStart xml:lang="en" />
        <includedActivitiesEnd xml:lang="en">The dataset describes the production of titanium zinc alloy from primary zinc and the fabrication of titanium zinc pla
        <generalComment>
          <text xml:lang="en" index="2">[This is a dataset transferred from ecoSpold v1 / ecoinvent database version 2. It may not in all aspects fulfill the requi
          <text xml:lang="en" index="1">The production steps pre-alloying, melting, casting, rolling, coiling, stretch forming and cutting are approximated using "
        </generalComment>
        <tag>ConvertedDataset</tag>
      </activity>
      <classification classificationId="aeaec32d-b5a4-44e0-bb50-25c0f4fe3d37">
        <classificationSystem xml:lang="en">EcoSpold01Categories</classificationSystem>
        <classificationValue xml:lang="en">metals/extraction</classificationValue>
      </classification>
      <classification classificationId="6fe7bc2b-4be4-48f7-92b0-f27dea9053ce">
        <classificationSystem xml:lang="en">ISIC rev.4 ecoinvent</classificationSystem>
        <classificationValue xml:lang="en">2420:Manufacture of basic precious and other non-ferrous metals</classificationValue>
      </classification>
      <geography geographyId="0e0e1020-7d7e-11de-9ae2-0019e336be3a">
        <shortname xml:lang="en">DE</shortname>
        <comment>
          <text xml:lang="en" index="1">Data from a leading titan zinc plate producer in Germany. Applicable for Europe.</text>
        </comment>
      </geography>
      <technology technologyLevel="3">
        <comment>
          <text xml:lang="en" index="1">Induction furnace for all the pre-alloying and melting steps, roll stands with 5 rolling pairs for the rolling step. Coilin
        </comment>
      </technology>
      <timePeriod startDate="1997-01-01" endDate="2013-12-31" isDataValidForEntirePeriod="false" />
      <macroEconomicScenario macroEconomicScenarioId="d9f57f0a-a01f-42eb-a57b-8f18d6635801">
        <name xml:lang="en">Business-as-Usual</name>
      </macroEconomicScenario>
    </activityDescription>
    <flowData>
      <intermediateExchange id="8fcd8ca4-28b0-46dd-bf9e-54c44bc0c82e" unitId="487df68b-4994-4027-8fdc-a4dc298257b7" casNumber="007440-66-6" amount="1.06" intermedi
        <name xml:lang="en">zinc</name>
        <unitName xml:lang="en">kg</unitName>
        <comment xml:lang="en">(1,4,1,3,1,5,3)</comment>
        <comment>EcoSpold01Location=RER</comment>
        <uncertainty>
          <lognormal meanValue="1.06" mu="0.06" variance="0.01" varianceWithPedigreeUncertainty="0.0121" />
```

EcoSpold 2

- Flow properties (before only in ILCD format): water content, etc., different units possible


```xml
<elementaryExchange id="d567a064-d1e0-4905-96e5-23f4684d10f4" unitId="487df68b-4994-4027-8fdc-a4dc298257b7" casNumber="022537-50-4" amount="1.5714E-07" eleme
  <name xml:lang="en">Tin, ion</name>
  <unitName xml:lang="en">kg</unitName>
  <comment xml:lang="en">This flow is issued during the process "contouring, brass". Contouring, brass is used as a proxy for rolling and colling of titanium
  <uncertainty>
    <lognormal meanValue="1.5714E-07" mu="-15.67" variance="0.81" varianceWithPedigreeUncertainty="1.02" />
    <pedigreeMatrix reliability="5" completeness="5" temporalCorrelation="5" geographicalCorrelation="5" furtherTechnologyCorrelation="5" />
  </uncertainty>
  <property propertyId="c74c3729-e577-4081-b572-a283d2561a75" amount="0" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45">
    <name xml:lang="en">carbon content, fossil</name>
    <unitName xml:lang="en">dimensionless</unitName>
  </property>
  <property propertyId="6d9e1462-80e3-4f10-b3f4-71febd6f1168" amount="0" unitId="487df68b-4994-4027-8fdc-a4dc298257b7">
    <name xml:lang="en">water in wet mass</name>
    <unitName xml:lang="en">kg</unitName>
  </property>
  <property propertyId="67f102e2-9cb6-4d20-aa16-bf74d8a03326" amount="1" unitId="487df68b-4994-4027-8fdc-a4dc298257b7">
    <name xml:lang="en">wet mass</name>
    <unitName xml:lang="en">kg</unitName>
  </property>
  <property propertyId="6393c14b-db78-445d-a47b-c0cb866a1b25" amount="0" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45">
    <name xml:lang="en">carbon content, non-fossil</name>
    <unitName xml:lang="en">dimensionless</unitName>
  </property>
  <property propertyId="a9358458-9724-4f03-b622-106eda248916" amount="0" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45">
    <name xml:lang="en">water content</name>
    <unitName xml:lang="en">dimensionless</unitName>
  </property>
  <property propertyId="3a0af1d6-04c3-41c6-a3da-92c4f61e0eaa" amount="1" unitId="487df68b-4994-4027-8fdc-a4dc298257b7">
    <name xml:lang="en">dry mass</name>
    <unitName xml:lang="en">kg</unitName>
  </property>
  <property propertyId="a301a838-7975-4d89-9e74-8eb77ad03cd1" amount="0" isDefiningValue="false" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45">
    <name xml:lang="en">carbon content</name>
    <unitName xml:lang="en">dimensionless</unitName>
    <comment xml:lang="en">carbon content on a dry matter basis (reserved; not for manual entry)</comment>
  </property>
  <property propertyId="f2283db2-62e4-467f-b9ac-c4f45be563b4" amount="0" isDefiningValue="false" unitId="487df68b-4994-4027-8fdc-a4dc298257b7">
    <name xml:lang="en">carbon allocation</name>
    <unitName xml:lang="en">kg</unitName>
    <comment xml:lang="en">carbon content per unit of product (reserved; not for manual entry)</comment>
  </property>
  <compartment subcompartmentId="e47f0a6c-3be8-4027-9eee-de251784f708">
    <compartment xml:lang="en">water</compartment>
    <subcompartment xml:lang="en">unspecified</subcompartment>
```

EcoSpold 2

- Flow properties: details for each process data set
  - e.g.: Flow: “Tin, ion”; Summary: water content (0), C content (0), etc. (!)


```xml
<elementaryExchange id="d567a064-d1e0-4905-96e5-23f4684d10f4" unitId="487df68b-4994-4027-8fdc-a4dc298257b7" casNumber="022537-50-4" amount="1.5714E-07" eleme
  <name xml:lang="en">Tin, ion</name>
  <unitName xml:lang="en">kg</unitName>
  <comment xml:lang="en">This flow is issued during the process "contouring, brass". Contouring, brass is used as a proxy for rolling and colling of titaniu
  <uncertainty>
    <lognormal meanValue="1.5714E-07" mu="-15.67" variance="0.81" varianceWithPedigreeUncertainty="1.02" />
    <pedigreeMatrix reliability="5" completeness="5" temporalCorrelation="5" geographicalCorrelation="5" furtherTechnologyCorrelation="5" />
  </uncertainty>
  <property propertyId="c74c3729-e577-4081-b572-a283d2561a75" amount="0" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45">
    <name xml:lang="en">carbon content, fossil</name>
    <unitName xml:lang="en">dimensionless</unitName>
  </property>
  <property propertyId="6d9e1462-80e3-4f10-b3f4-71febd6f1168" amount="0" unitId="487df68b-4994-4027-8fdc-a4dc298257b7">
    <name xml:lang="en">water in wet mass</name>
    <unitName xml:lang="en">kg</unitName>
  </property>
  <property propertyId="67f102e2-9cb6-4d20-aa16-bf74d8a03326" amount="1" unitId="487df68b-4994-4027-8fdc-a4dc298257b7">
    <name xml:lang="en">wet mass</name>
    <unitName xml:lang="en">kg</unitName>
  </property>
  <property propertyId="6393c14b-db78-445d-a47b-c0cb866a1b25" amount="0" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45">
    <name xml:lang="en">carbon content, non-fossil</name>
    <unitName xml:lang="en">dimensionless</unitName>
  </property>
  <property propertyId="a9358458-9724-4f03-b622-106eda248916" amount="0" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45">
    <name xml:lang="en">water content</name>
    <unitName xml:lang="en">dimensionless</unitName>
  </property>
  <property propertyId="3a0af1d6-04c3-41c6-a3da-92c4f61e0eaa" amount="1" unitId="487df68b-4994-4027-8fdc-a4dc298257b7">
    <name xml:lang="en">dry mass</name>
    <unitName xml:lang="en">kg</unitName>
  </property>
  <property propertyId="a301a838-7975-4d89-9e74-8eb77ad03cd1" amount="0" isDefiningValue="false" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45">
    <name xml:lang="en">carbon content</name>
    <unitName xml:lang="en">dimensionless</unitName>
    <comment xml:lang="en">carbon content on a dry matter basis (reserved; not for manual entry)</comment>
  </property>
  <property propertyId="f2283db2-62e4-467f-b9ac-c4f45be563b4" amount="0" isDefiningValue="false" unitId="487df68b-4994-4027-8fdc-a4dc298257b7">
    <name xml:lang="en">carbon allocation</name>
    <unitName xml:lang="en">kg</unitName>
    <comment xml:lang="en">carbon content per unit of product (reserved; not for manual entry)</comment>
  </property>
  <compartment subcompartmentId="e47f0a6c-3be8-4027-9eee-de251784f708">
    <compartment xml:lang="en">water</compartment>
    <subcompartment xml:lang="en">unspecified</subcompartment>
```

EcoSpold 2

- Flow properties: details for each process data set
  - Auto generated flow properties “EcoSpold01Allocation_undefined_xy“


```
    <outputGroup>2</outputGroup>
  </intermediateExchange>
  <intermediateExchange id="eb369ed2-ccf9-449f-b7ff-3a1eda104871" unitId="487df68b-4994-4027-8fdc-a4dc298257b7" amount="0" intermediateExc
    <name xml:lang="en">palladium</name>
    <unitName xml:lang="en">kg</unitName>
    <property propertyId="40ca2c51-2da6-4351-bd4c-d6f181fc7d55" amount="37.91">
      <name xml:lang="en">EcoSpold01Allocation_undefined_2</name>
    </property>
    <property propertyId="13706ab5-1a8c-42fd-8329-c93266943c87" amount="37.91">
      <name xml:lang="en">EcoSpold01Allocation_undefined_16</name>
    </property>
    <property propertyId="db2e27d1-47cd-4180-8416-4f79369de00c" amount="37.91">
      <name xml:lang="en">EcoSpold01Allocation_undefined_6</name>
    </property>
    <property propertyId="3db02346-808f-4eb6-9232-317a23c63484" amount="37.91">
      <name xml:lang="en">EcoSpold01Allocation_undefined_7</name>
    </property>
    <property propertyId="9909d836-d0a3-45ed-a8d6-62f5febc763e" amount="100">
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    </property>
    <property propertyId="9c38ea07-adcd-4018-8636-eb32382f39a7" amount="37.91">
      <name xml:lang="en">EcoSpold01Allocation_undefined_5</name>
    </property>
    <property propertyId="e2bdc7a2-bfb2-4db4-9fa2-12e46f767097" amount="37.91">
      <name xml:lang="en">EcoSpold01Allocation_undefined_19</name>
    </property>
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      <name xml:lang="en">EcoSpold01Allocation_undefined_8</name>
    </property>
    <property propertyId="a9358458-9724-4f03-b622-106eda248916" amount="0" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45">
      <name xml:lang="en">water content</name>
      <unitName xml:lang="en">dimensionless</unitName>
```

EcoSpold 2: "Intelligence" in data format

Child and parent data sets:

- "parent data set: a dataset referred to by a child dataset as the dataset from which field values in the child dataset are to be inherited to the extent defined, i.e. parent datasets serve as basis of their associated child datasets. " (ecoinvent.org)
- "Only geographical inheritance is allowed in the ecoinvent v3 database, i.e. some regional datasets (such as Brazilian soybean production) might be modelled as a child dataset of the global dataset. " (ecoinvent.org)

EcoSpold 2: “Intelligence” in data format

Child and parent data sets:

- “In child datasets values can be set to relate to the corresponding value in the parent dataset. When such a related value is changed in the parent dataset it is automatically changed in the child dataset as well.”
- “it is automatically changed” → better: it is meant to be automatically changed.
- Idea: save space; avoid redundancies.
- In current ecoinvent database: values for all the child data sets present; redundancies exist

→ (possible) task for software developers: keep redundant information consistent

Ecoinvent 3 market modeling

- Basically, products are not exchanged directly between processes, but through a market
  - Advantage: more flexible modeling of process chains
  - However, the current version is linked→ flexibility lost
  - But...different default "system models":

  "system model; a model describing how activity data sets are linked to form product systems. A system model may determine factors such as whether to use allocation (and which type of allocation) or substitution [...], or whether to use average or marginal suppliers. It may also affect how by-product treatments are assessed."

  - Originally two system models: "Allocation, ecoinvent default" and "Consequential, substitution, long-term".
    - From version 3.0.1 also "cut-off" model.

Ecoinvent 3 market modeling

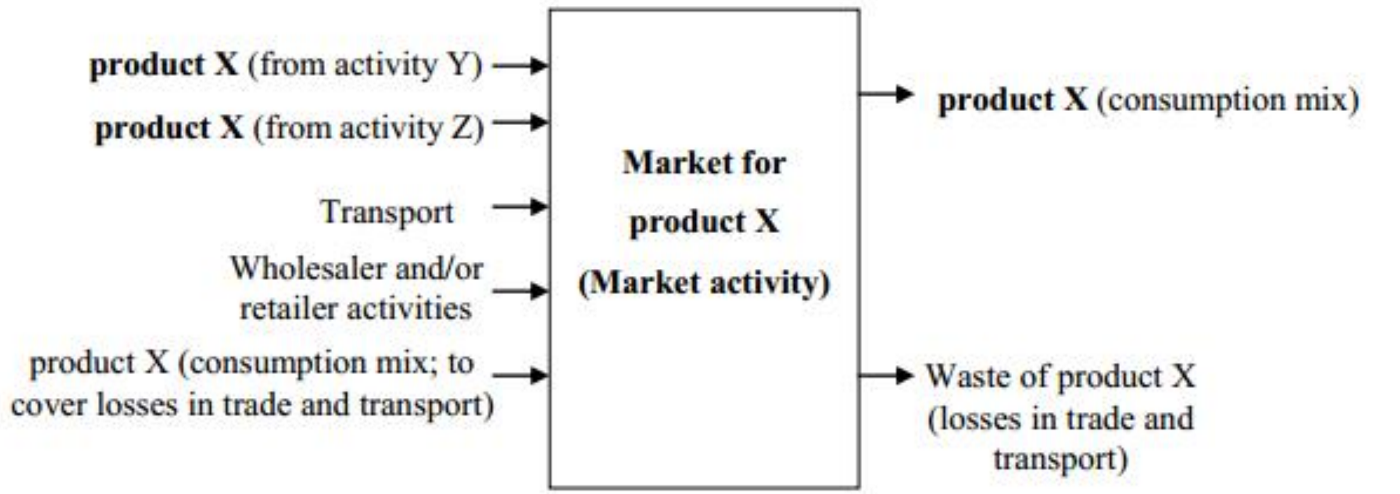
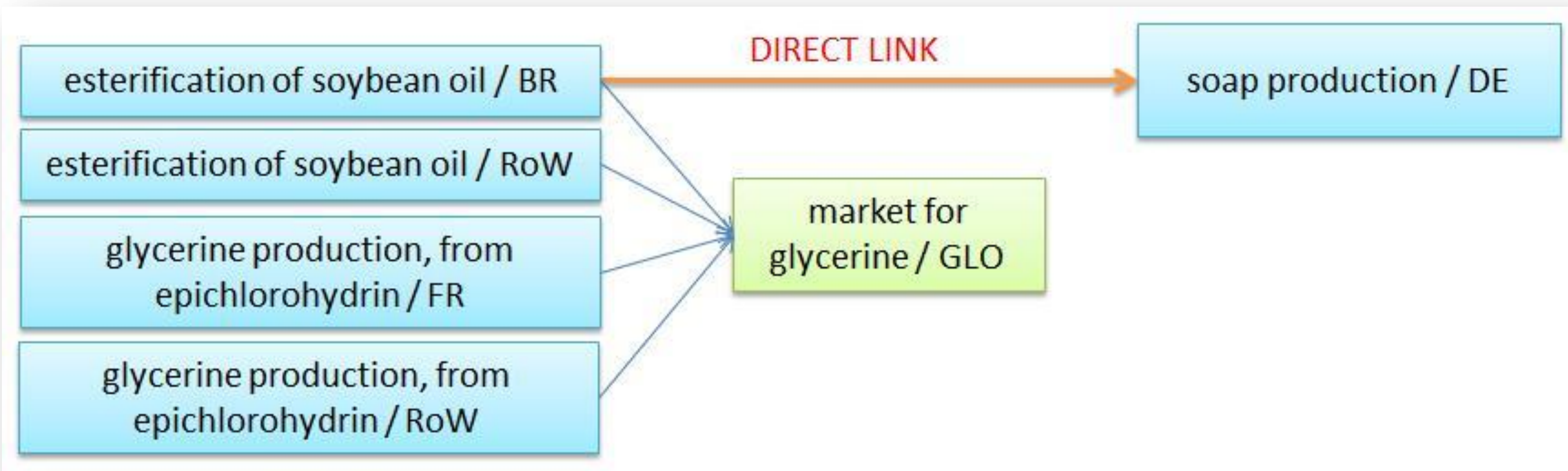


Figure 4.2. A market activity with its intermediate exchanges. Texts in brackets are not part of the name of the exchange.

(ecoinvent methodology report p.17)

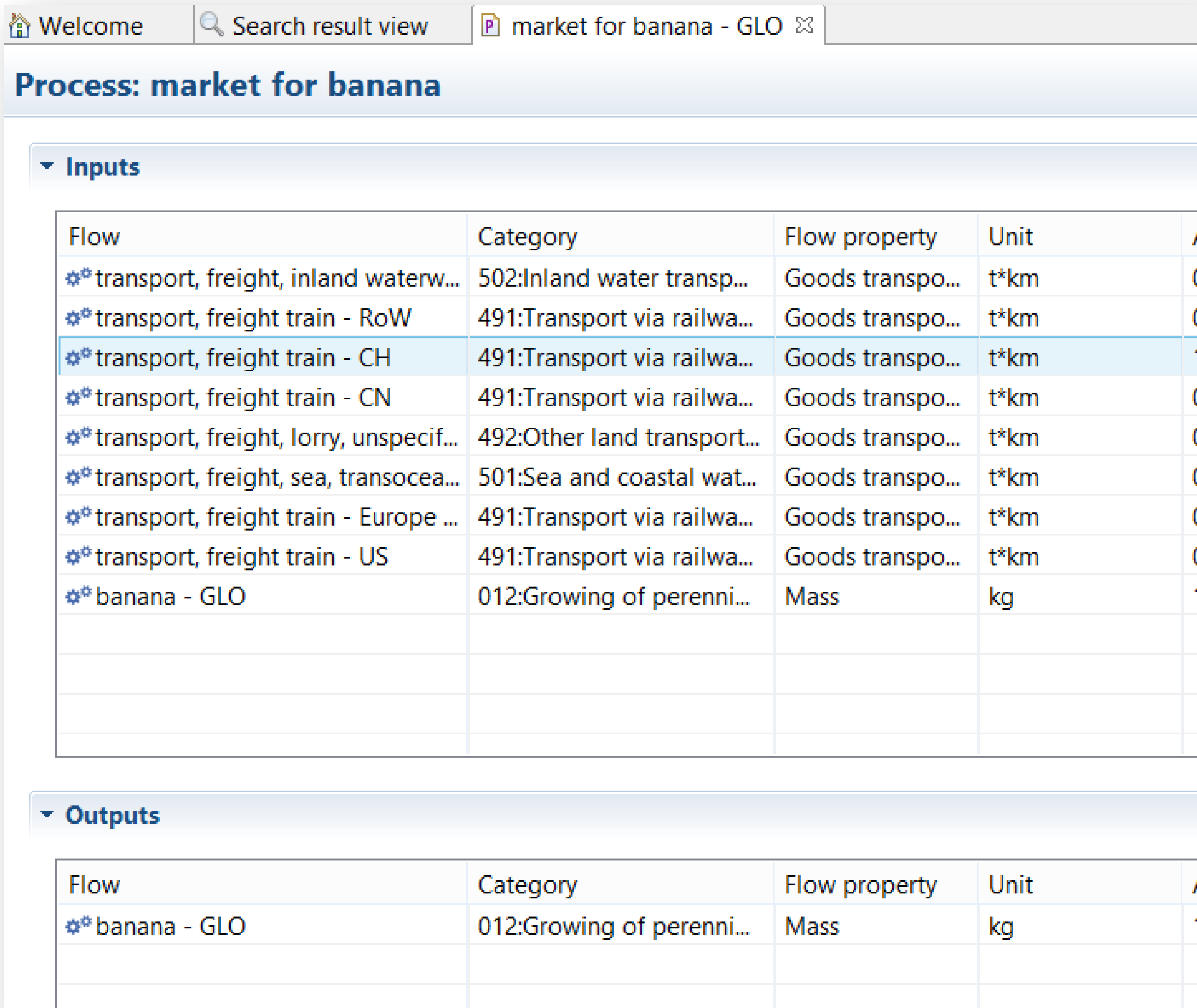
Ecoinvent 3 market modeling

- Example for the difference between each system model:
  - Direct link: Consequential model
  - Market: Attributional / default model



(ecoinvent.org)

Ecoinvent 3: e.g. market for banana



Welcome | Search result view | market for banana - GLO

Process: market for banana

Inputs

Flow	Category	Flow property	Unit	A
transport, freight, inland waterw...	502:Inland water transp...	Goods transpo...	t*km	0
transport, freight train - RoW	491:Transport via railwa...	Goods transpo...	t*km	0
transport, freight train - CH	491:Transport via railwa...	Goods transpo...	t*km	1
transport, freight train - CN	491:Transport via railwa...	Goods transpo...	t*km	0
transport, freight, lorry, unspecif...	492:Other land transport...	Goods transpo...	t*km	0
transport, freight, sea, transocea...	501:Sea and coastal wat...	Goods transpo...	t*km	0
transport, freight train - Europe ...	491:Transport via railwa...	Goods transpo...	t*km	0
transport, freight train - US	491:Transport via railwa...	Goods transpo...	t*km	0
banana - GLO	012:Growing of perenni...	Mass	kg	1

Outputs

Flow	Category	Flow property	Unit	A
banana - GLO	012:Growing of perenni...	Mass	kg	1

(ecoinvent 3.1 allocation default)

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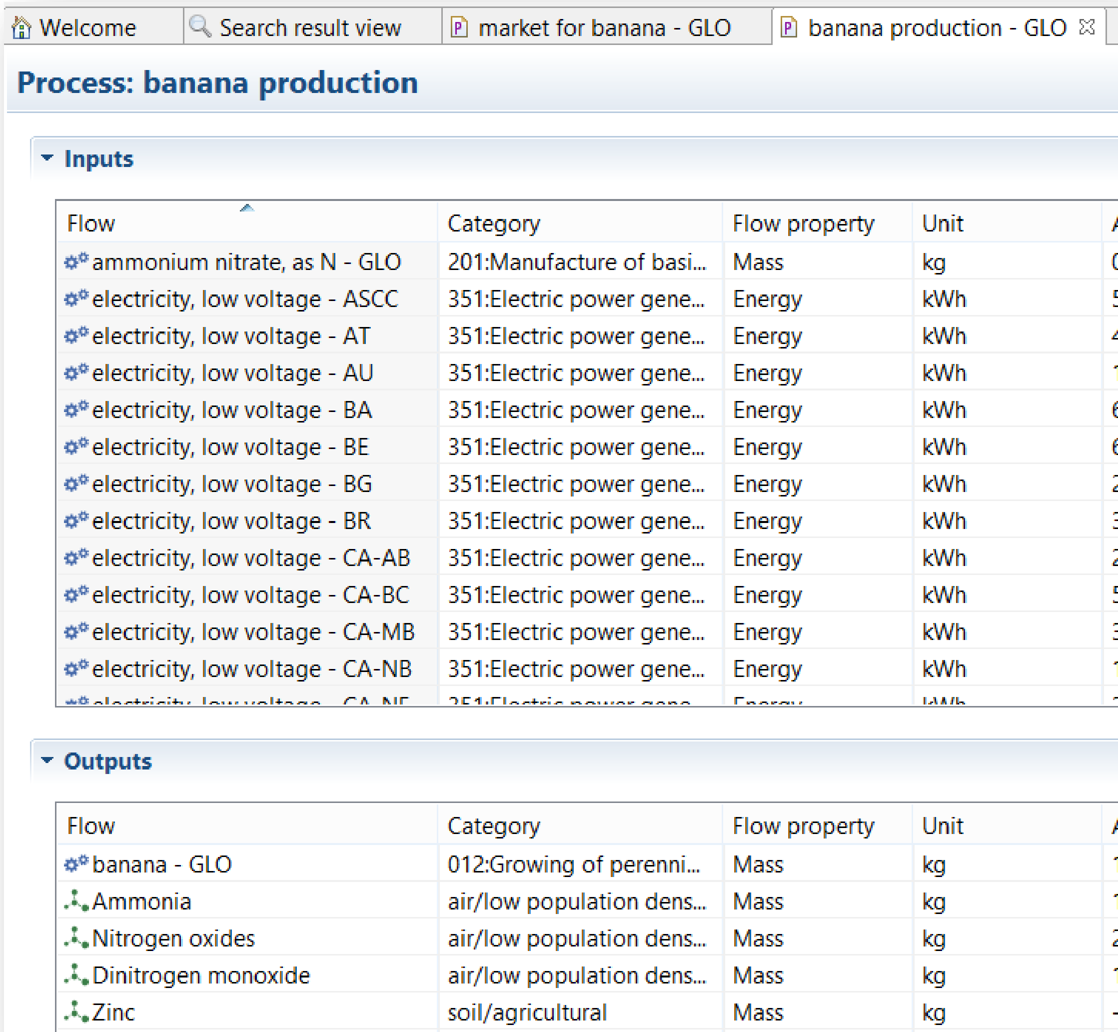
Ecoinvent 3: e.g. banana production



Process: banana production

Inputs

Flow	Category	Flow property	Unit	A
ammonium nitrate, as N - GLO	201:Manufacture of basi...	Mass	kg	0
electricity, low voltage - ASCC	351:Electric power gene...	Energy	kWh	5
electricity, low voltage - AT	351:Electric power gene...	Energy	kWh	4
electricity, low voltage - AU	351:Electric power gene...	Energy	kWh	1
electricity, low voltage - BA	351:Electric power gene...	Energy	kWh	6
electricity, low voltage - BE	351:Electric power gene...	Energy	kWh	6
electricity, low voltage - BG	351:Electric power gene...	Energy	kWh	2
electricity, low voltage - BR	351:Electric power gene...	Energy	kWh	3
electricity, low voltage - CA-AB	351:Electric power gene...	Energy	kWh	2
electricity, low voltage - CA-BC	351:Electric power gene...	Energy	kWh	5
electricity, low voltage - CA-MB	351:Electric power gene...	Energy	kWh	3
electricity, low voltage - CA-NB	351:Electric power gene...	Energy	kWh	1

Outputs

Flow	Category	Flow property	Unit	A
banana - GLO	012:Growing of perenni...	Mass	kg	1
Ammonia	air/low population dens...	Mass	kg	1
Nitrogen oxides	air/low population dens...	Mass	kg	2
Dinitrogen monoxide	air/low population dens...	Mass	kg	1
Zinc	soil/agricultural	Mass	kg	-

(ecoinvent 3.1 allocation default)

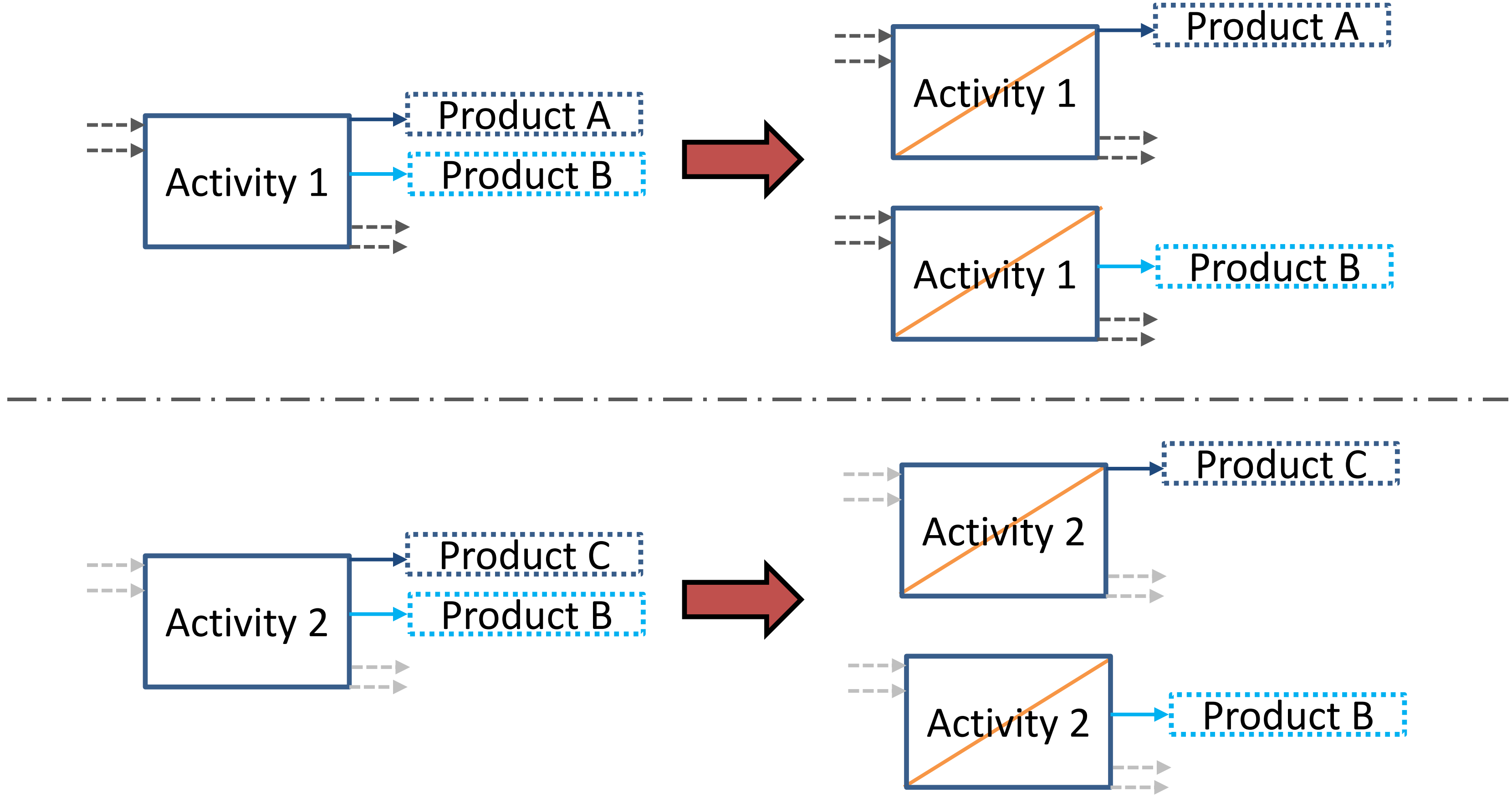
GreenDelta

Ecoinvent 3 System models

- Common rules:
  - By-products/wastes identified as materials for treatment are moved to the input with negative sign.
  - Intermediate inputs without activity link specified, are linked to the local market activity data set.
  - Data sets with “combined” products are divided into an equivalent number of data sets.
  - For “joint” products:
    → Allocation (partitioning)
    → System expansion (substitution)

Ecoinvent 3 Allocation model

– Divide the data sets into new activities according the allocation factor



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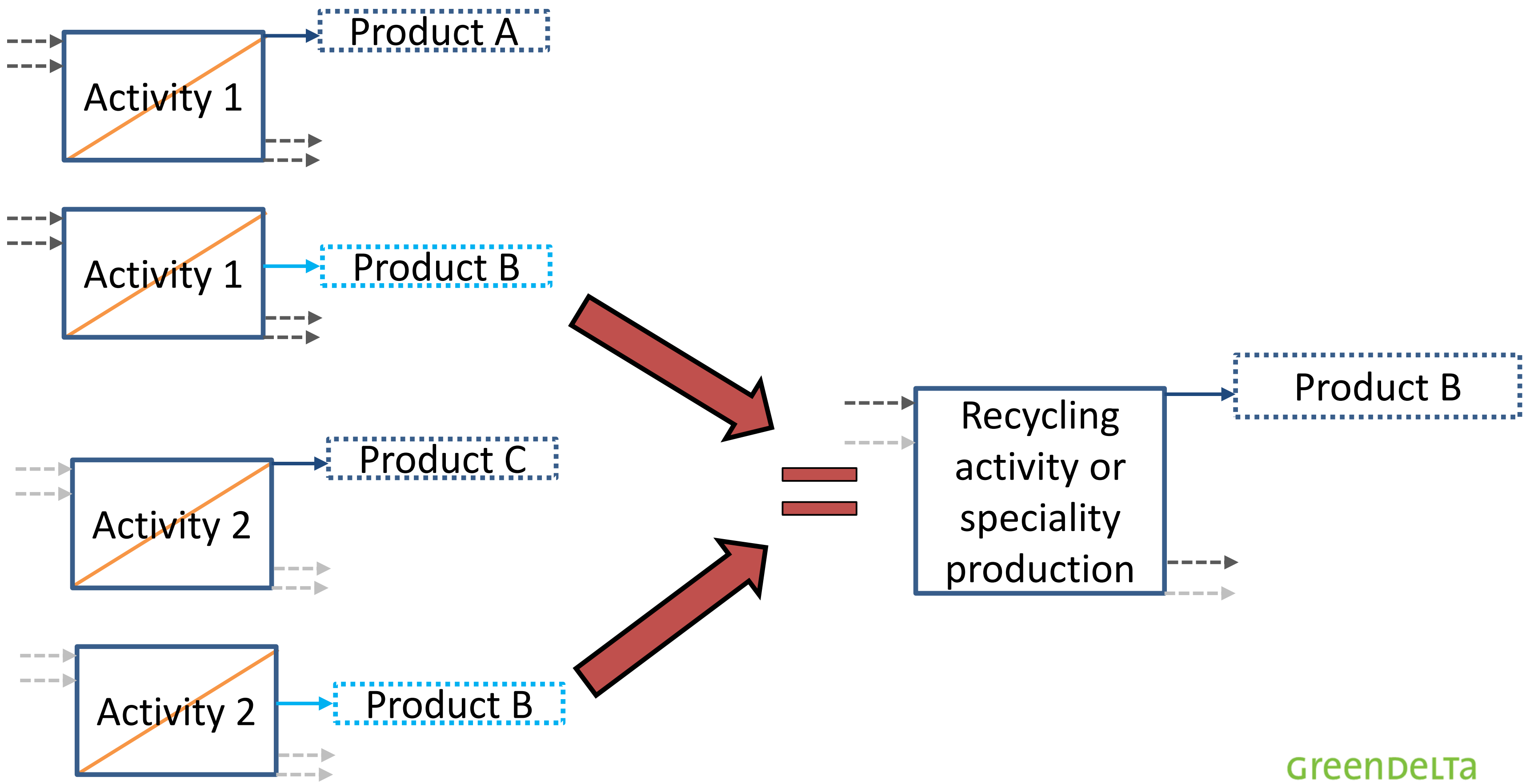
Ecoinvent 3 Allocation model

– After allocation, all activities producing the same marketable by-product yielded from a treatment activity get aggregated and are grouped into a single dataset



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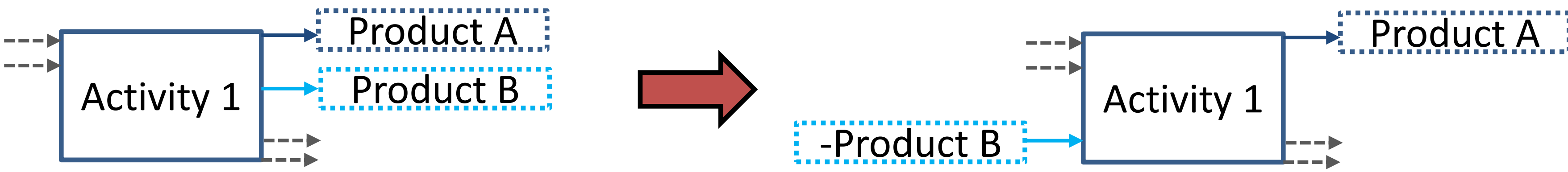
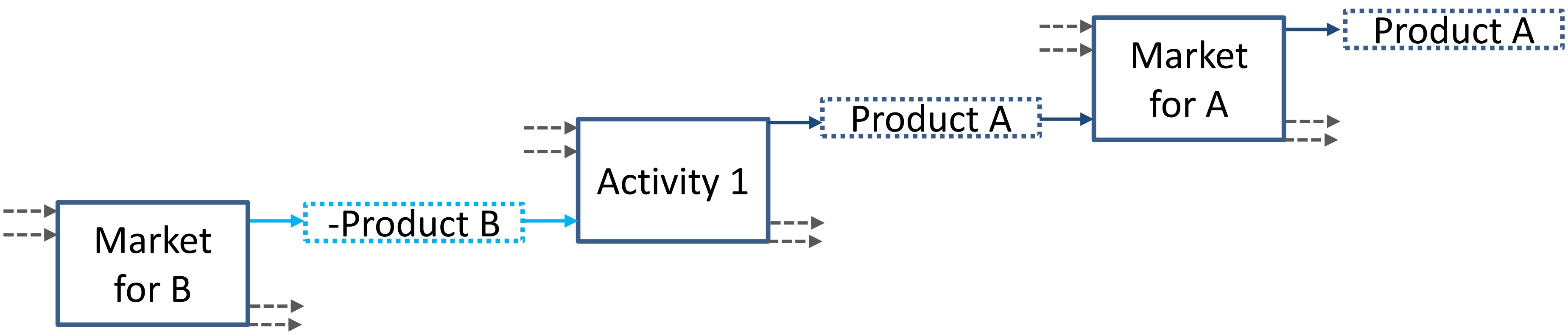
Ecoinvent 3 Substitution model

– All by-products are moved to the input side with negative sign



– All inputs and outputs are linked to their corresponding market activities



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Ecoinvent 3 Cut-off model

- Based on the Recycled Content, or Cut-off, approach.
- Primary (first) production of materials is always allocated to the primary user of a material.
- If a material is recycled, the primary producer does not receive any credit for the provision of any recyclable materials. As a consequence, recyclable materials are available burden-free to recycling processes, and secondary (recycled) materials bear only the impacts of the recycling processes.
- Furthermore, producers of wastes do not receive any credit for recycling or re-use of products resulting out of any waste treatment.

e.g.: recycled paper? Waste incineration?

Ecoinvent 3 Cut-off model (II)

- All technosphere flows are classified as:
  - ordinary by-product (treated just as common products, but they are not reference)
  - recyclable material ("Materials with no or little economic value that can serve as the input or resource for a recycling activity"), or
  - waste ("Materials with no economic value, and no interest in their collection without compensation")

(http://www.ecoinvent.org/fileadmin/documents/en/System_Models/System_model_description_and_specification-Cutoff.pdf)

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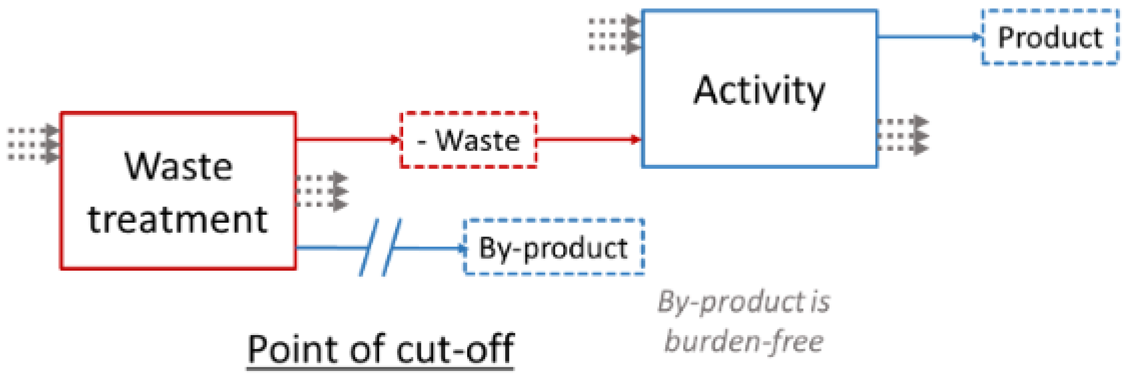
Ecoinvent 3 Cut-off model (III)

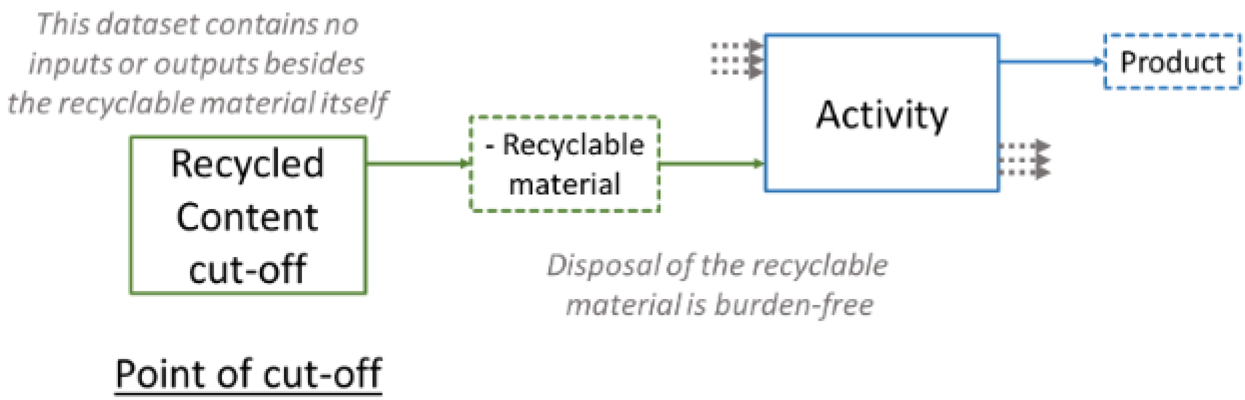
– Waste products handling: by-product is burden-free



(http://www.ecoinvent.org/fileadmin/documents/en/System_Models/System_model_description_and_specification-Cutoff.pdf)

Ecoinvent 3 Cut-off model (IV)

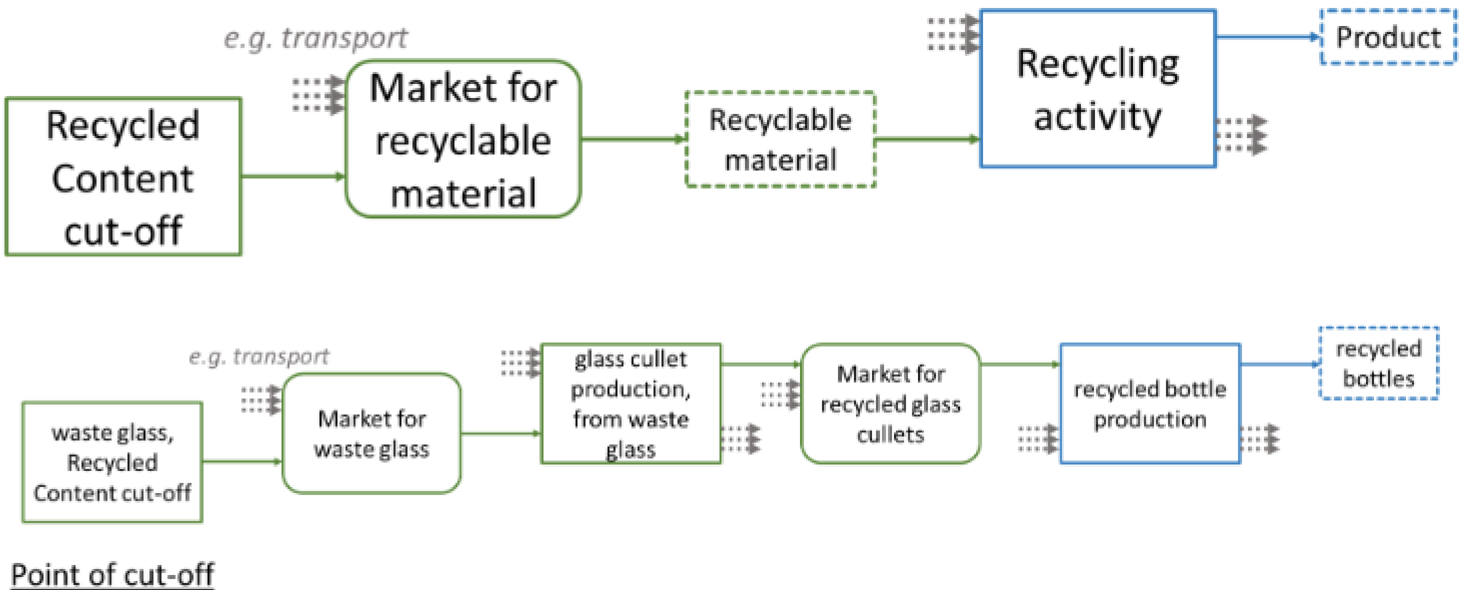
– Handling of recyclable materials: negative input (=output) of a dummy process recycled content cut-off



(http://www.ecoinvent.org/fileadmin/documents/en/System_Models/System_model_description_and_specification-Cutoff.pdf)

Ecoinvent 3 Cut-off model (V)

– Handling of recyclable materials: when used in markets, markets get additional transport effort as usual



(http://www.ecoinvent.org/fileadmin/documents/en/System_Models/System_model_description_and_specification-Cutoff.pdf)

Ecoinvent 3 New data

- (very few: some international data; water data)

- Data updates
  - e.g. electricity mixes, transport

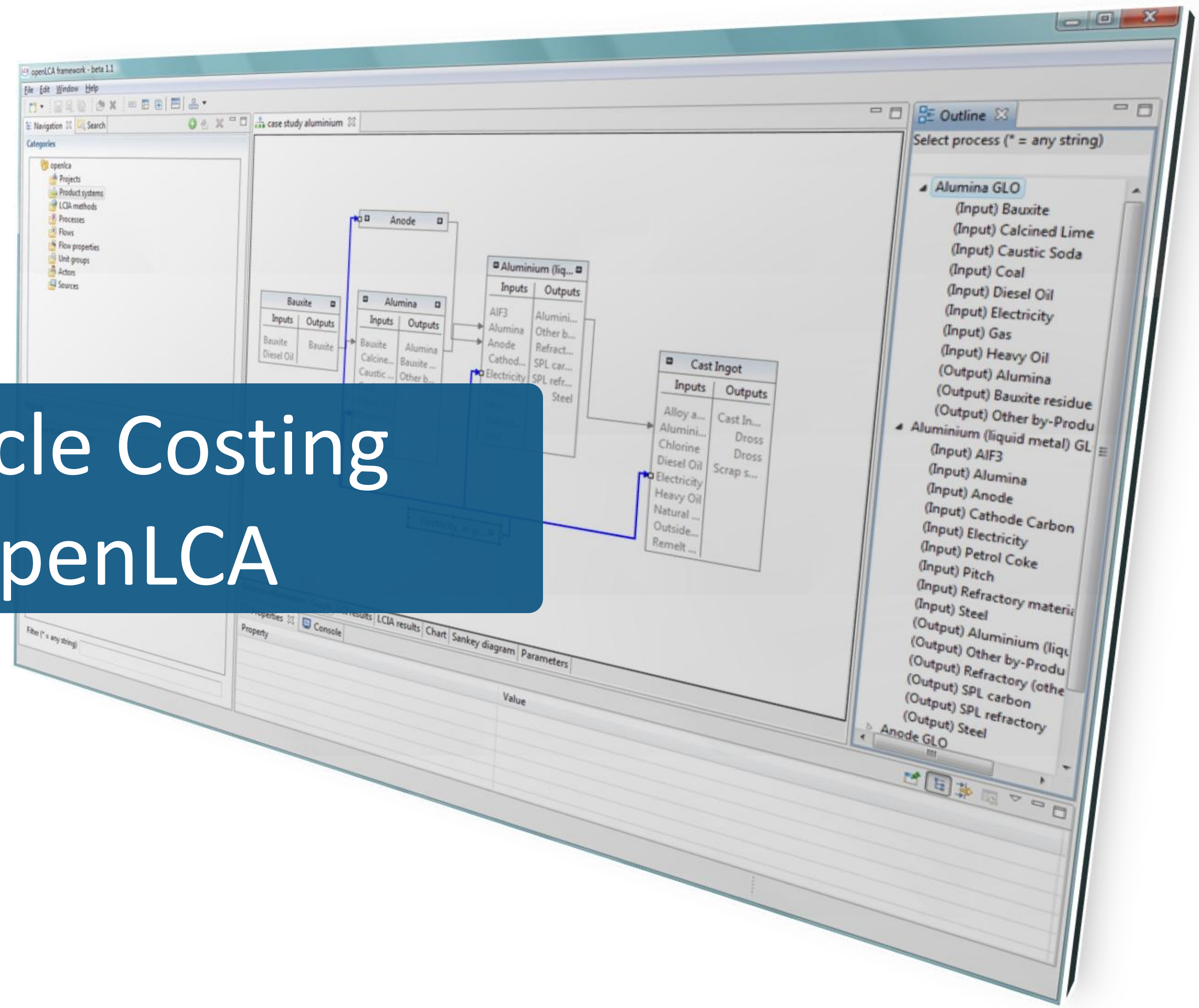
Ecoinvent 3 Consequences for openLCA

- Much larger systems

  → Optimization of performance in product sytems (open, create new): before 2 min, now 10s

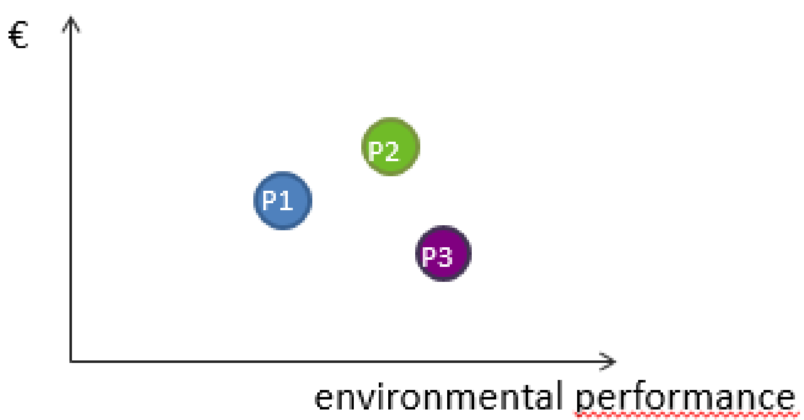
  → Optimization of the calculation (Background: matrix inversion, memory use, speed)
- modeling corrections (correct some links; uncertainty information)
- (openLCA structure adapts well already)

Life Cycle Costing in openLCA



Motivation of LCC

- LCC gives an overview over all costs that arise through the entire life cycle of a product.
- 2 perspectives: manufacturer and consumer
- Important for goods that entail high costs through maintenance (e.g. car or train) or for the comparison of different products
- LCC can be used for the calculation of eco-efficiency



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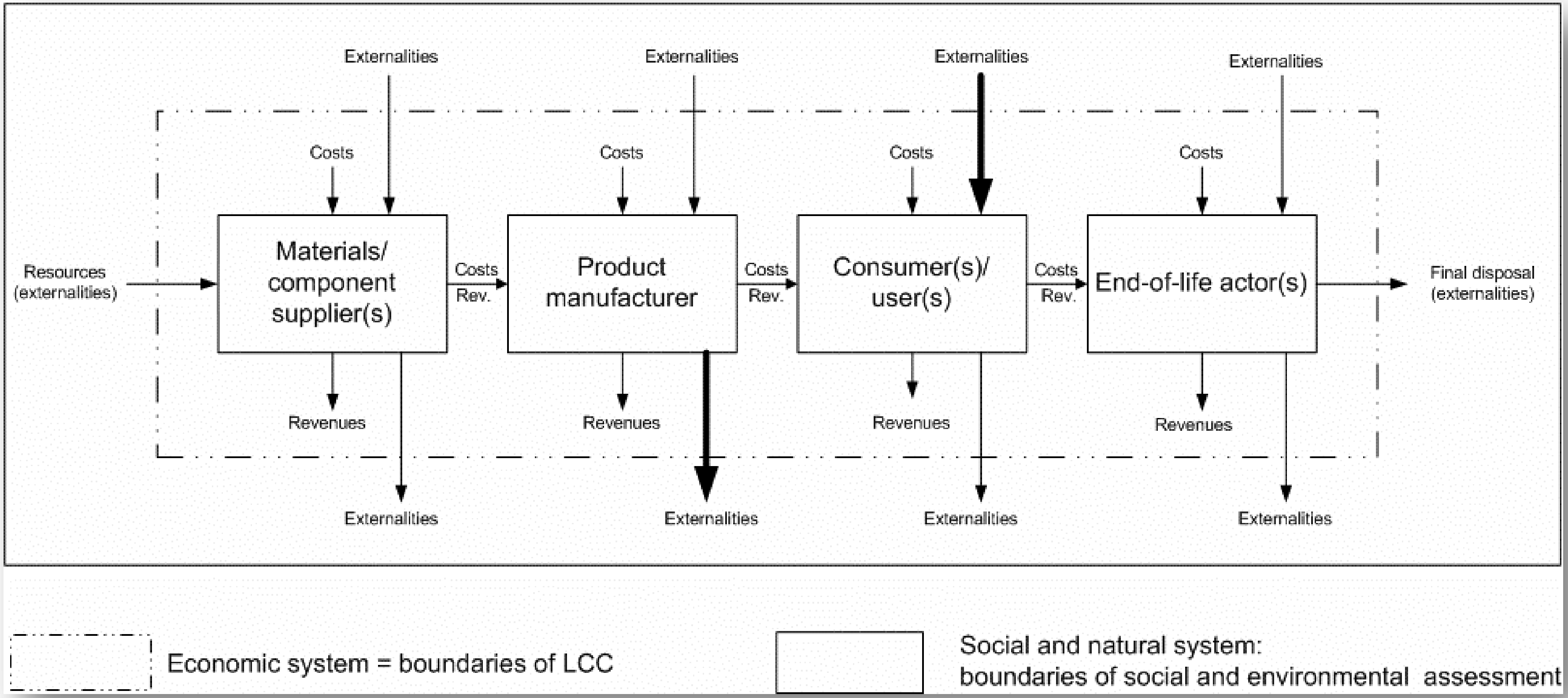
Example: The consumer perspective

	Opel Corsa	Fiat Punto	Citroen Advance
Purchase price	10,945 €	10,890 €	10,9990 €
Costs per year			
Buy price	1,977 €	2,164 €	1,936 €
Taxes, insurance, etc.	1,753 €	1,911 €	1,527 €
Operating costs	909 €	964 €	998 €
Repair costs	352 €	490 €	318 €
Total yearly costs	**4,991 €**	**5,529 €**	**4,779 €**

Scope of LCC



Source: Rebitzer G., Hunkeler D. (2003): Life Cycle Costing in LCM: Ambitions, opportunities, and limitations, Discussing a framework, In: Int J LCA 8 (5), pp. 253-256

LCC in openLCA

- Two possibilities:
  1. Costs are treated as environmental impacts (costs are emissions)
     - » Costs are considered as elementary flows
  2. Use of the costs tab in the process editor
     - » Only cost categories can be considered

The costs tab option is currently only included for process documentation purposes → No calculation is available!

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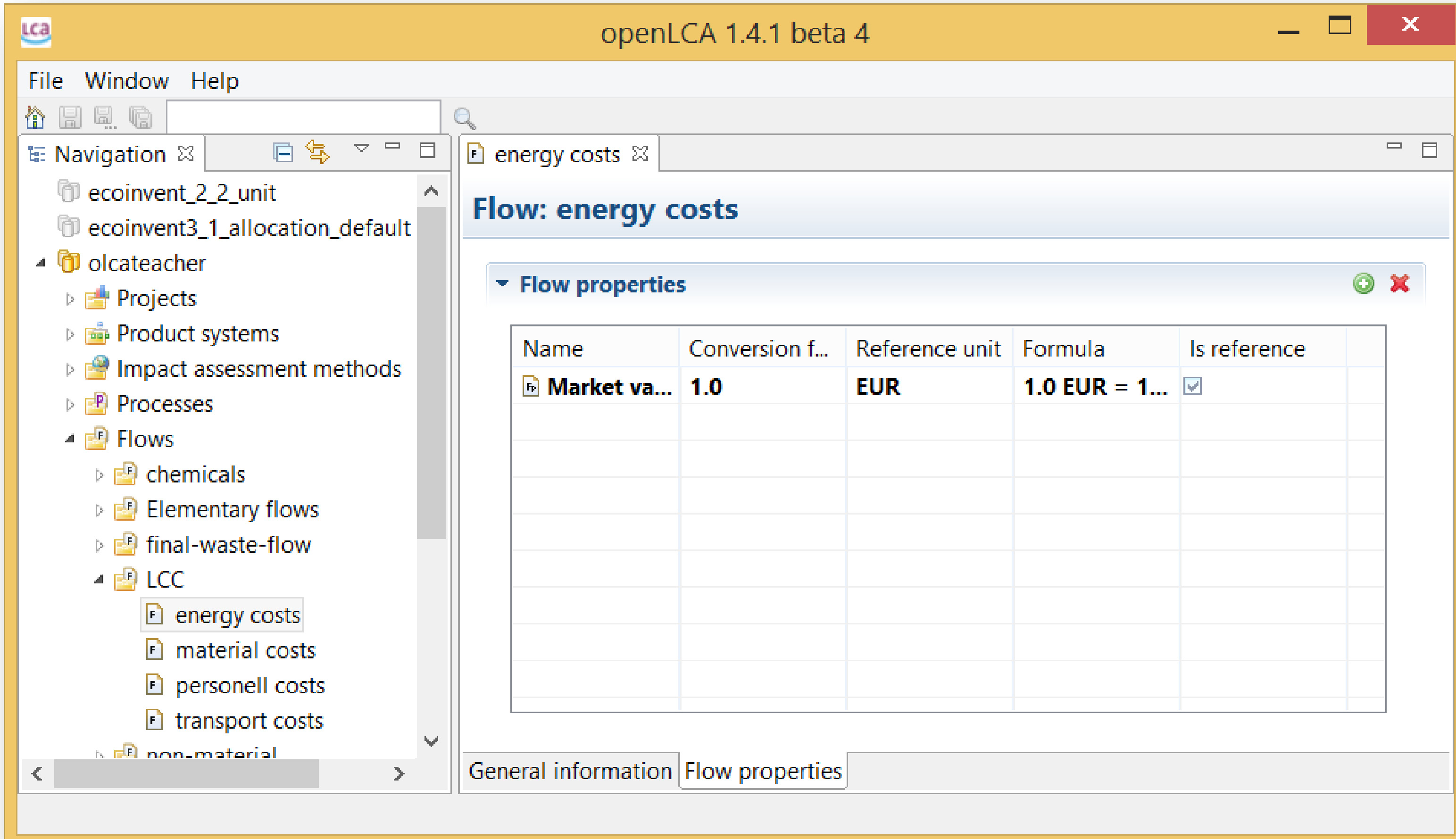
Option 1: Costs as elementary flows

- In a first step, specific or general cost flows are defined (e.g. [(material costs) for PET], [(labour costs) for engineers], [(transport costs) for road transportation], etc.).
- These cost flows are assigned to processes (treated as emissions).
- It is recommended to create a new impact assessment method which adds up the cost flows. Different cost categories (→ impact categories) can be defined (e.g. manufacturing costs, transport costs, disposal costs, ...)

Option 1: Procedure in openLCA (I)

– Creation of costs flows as elementary flows



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Option 1: Procedure in openLCA (II)

– Adding costs flows to processes (outputs)

Process: Blade, steel LCC

Inputs

Flow	Category	Flow proper...	Unit	Amount	Uncertainty	Defaul
Steel, billets, at plant - US	Product flows	Mass	g	2	none	
Electricity, at grid, CN	Product flows	Energy	kWh	0.05	none	

Outputs

Flow	Category	Flow proper...	Unit	Amount	Uncertainty	Avoide
Blade, steel_LCC	Product flows	Number of ...	Item(s)	1	none	
energy costs	LCC	Market valu...	EUR	0.2*0.05	none	
personell costs	LCC	Market valu...	EUR	0.004	none	
material costs	LCC	Market valu...	EUR	0.02*0.90	none	

Option 1: Procedure in openLCA (III)

– Creation of an impact assessment method

Impact categories

Name	Description	Reference unit
Energy costs		EUR
Material costs		EUR
Personnel costs		EUR
Transport costs		EUR

Impact assessment method: LCC

Impact factors

Impact category: Energy costs

Flow	Category	Flow property	Unit	Factor	Uncertainty
energy costs	LCC	Market value US 2000, bulk prices	EUR/EUR	1.0	none

Option 1: Procedure in openLCA (IV)

– Calculate the product system costs results with the new LCIA method

LCIA Results

LCIA Results

Impact category	Result	Reference unit
Material costs	0.21268	EUR
Transport costs	0.05000	EUR
Personnel costs	0.10050	EUR
Energy costs	0.06646	EUR

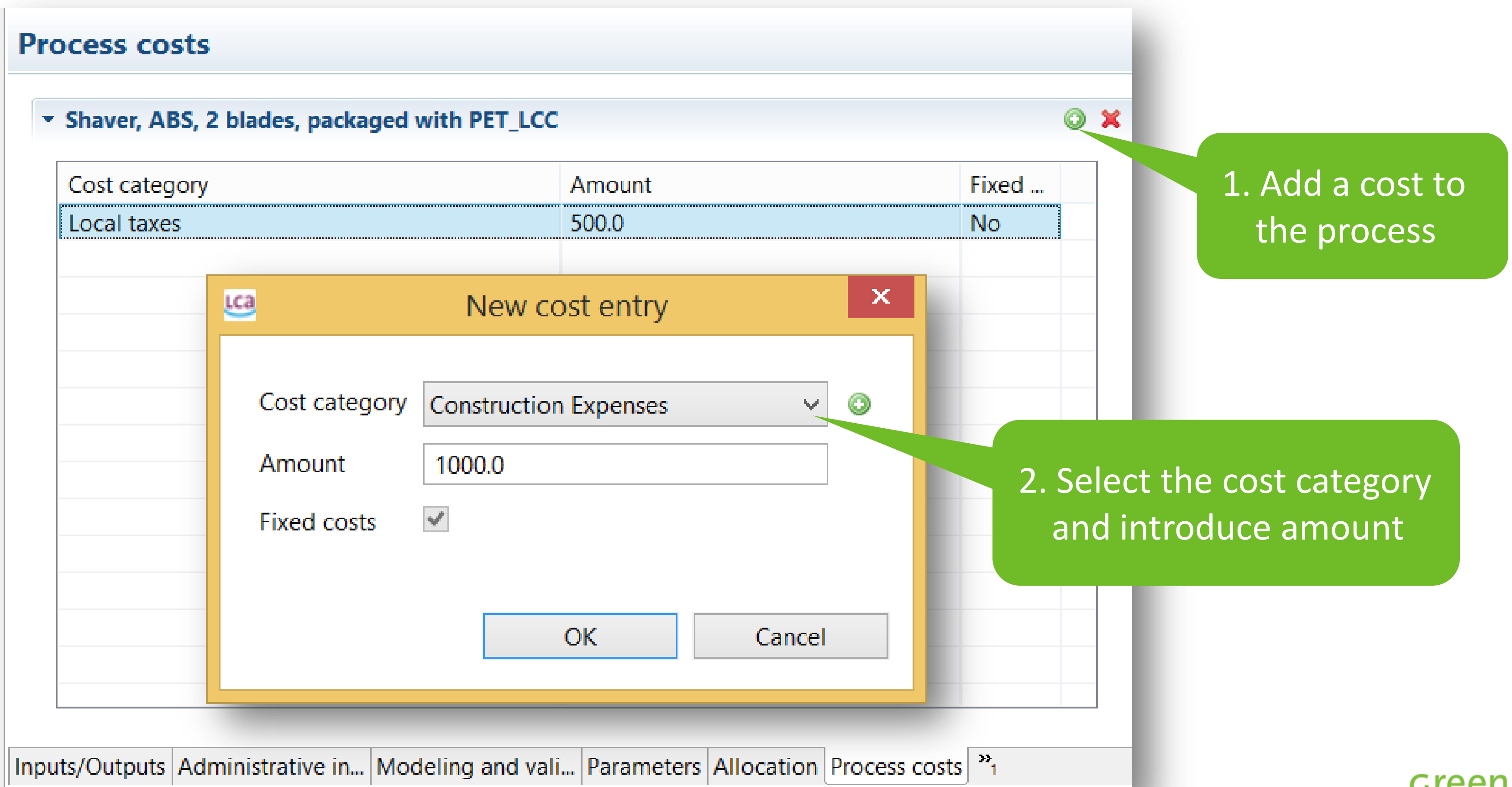
Impact contributions

Impact category: Material costs

Contribution	Process	Amount	Unit
74.99%	Use phase shaver, ABS, 2 blades LCC - US	0.15950	EUR
16.93%	Blade, steel LCC - GLO	0.03600	EUR
07.50%	Shaver handle, ABS LCC - GLO	0.01595	EUR

Option 2: Costs tab in the process editor

– Cost categories are defined on the process level. Values are assigned to these cost categories.



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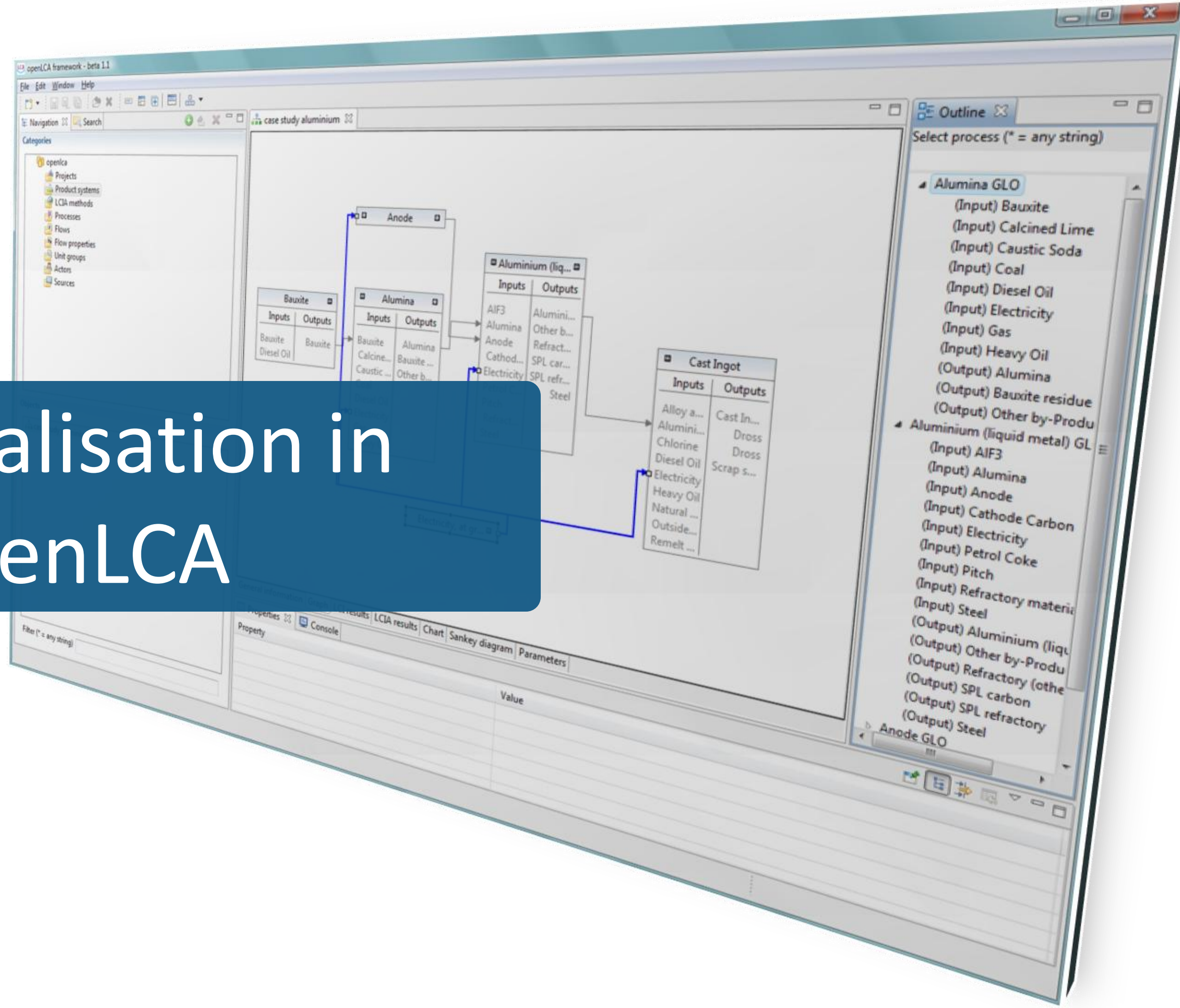
Regionalisation in openLCA



Regionalised LCIA is model sophistication

- Commonly, in Life Cycle Assessment (LCA), the impact assessment (LCIA) is performed ignoring any regional differences.

- Differences in the inventory are considered as far as possible (e.g., different processes for electricity generation, in different countries...)

- There are good reasons for considering a regional variation in the impact assessment, but this adds complexity

→ When does this make sense?

Good reasons for regionalised LCIA

- Withdrawal of 1l of water for agriculture

source: dennis140, aloe vera plantage, Fuerteventura (left); Gario, cows meadow, Texel (right)

GreenDelta

Good reasons for regionalised LCIA

- Fine particles emissions to air

source: Berserkerus, GPL, Peking smog (left); Petra, CCo, sand storm, Jordania (right)

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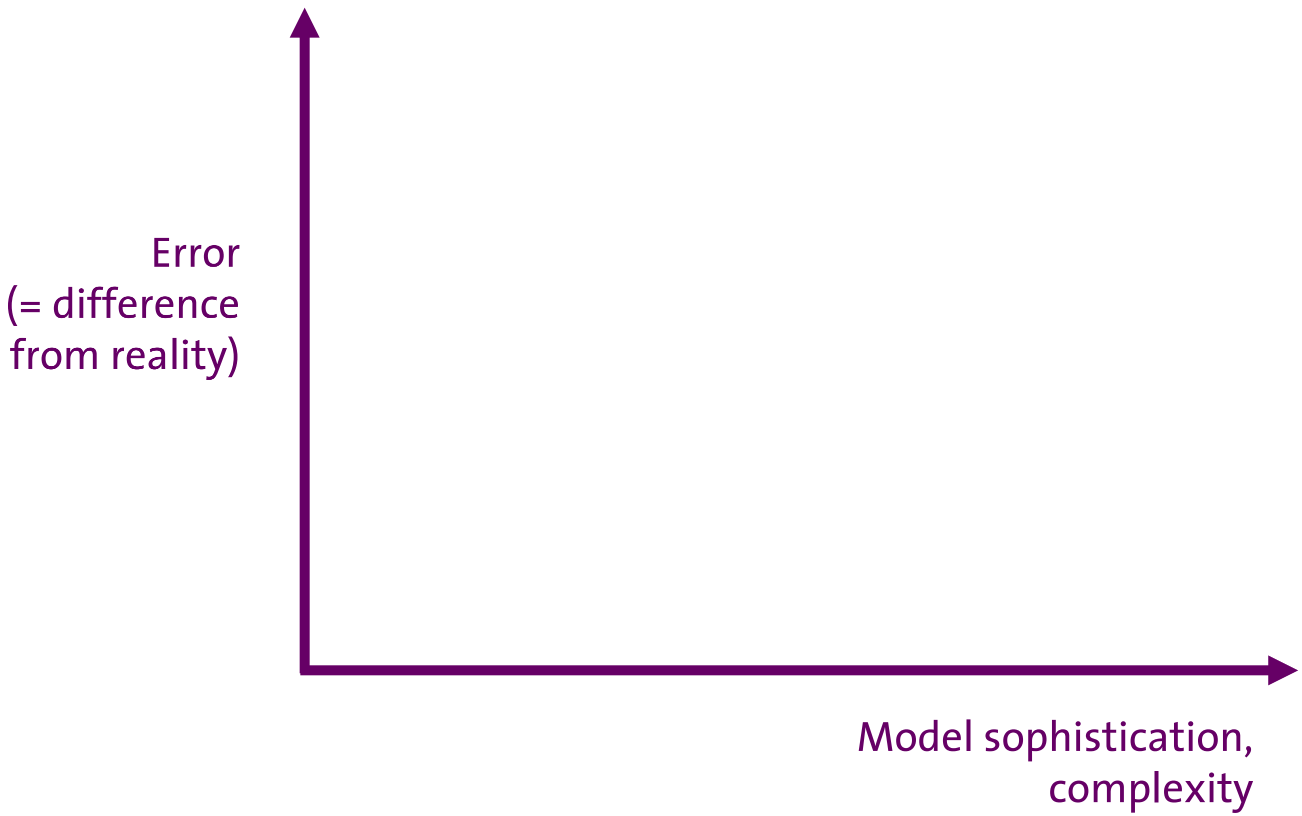
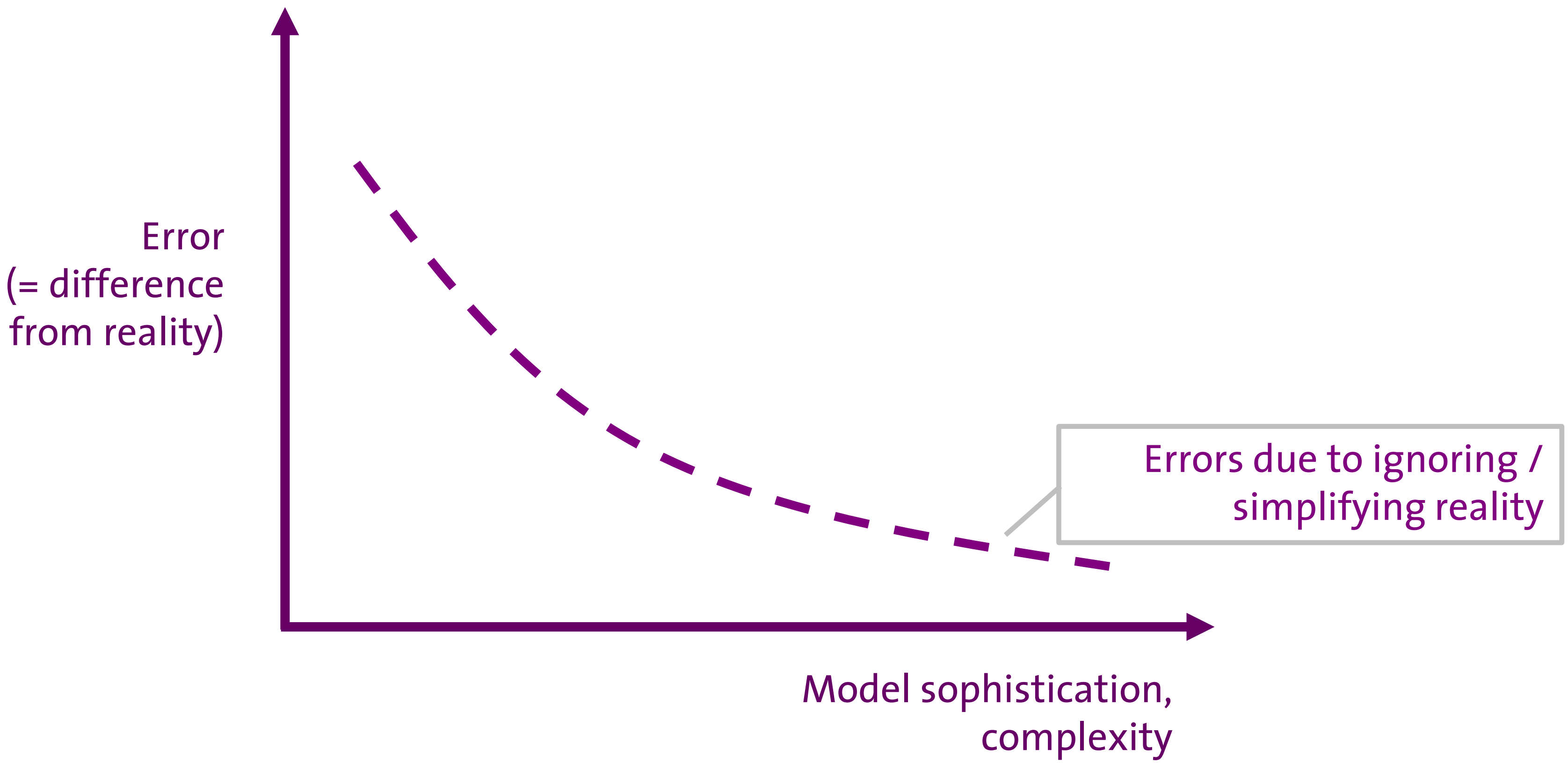
When does regionalised LCIA make sense?



When does regionalised LCIA make sense?



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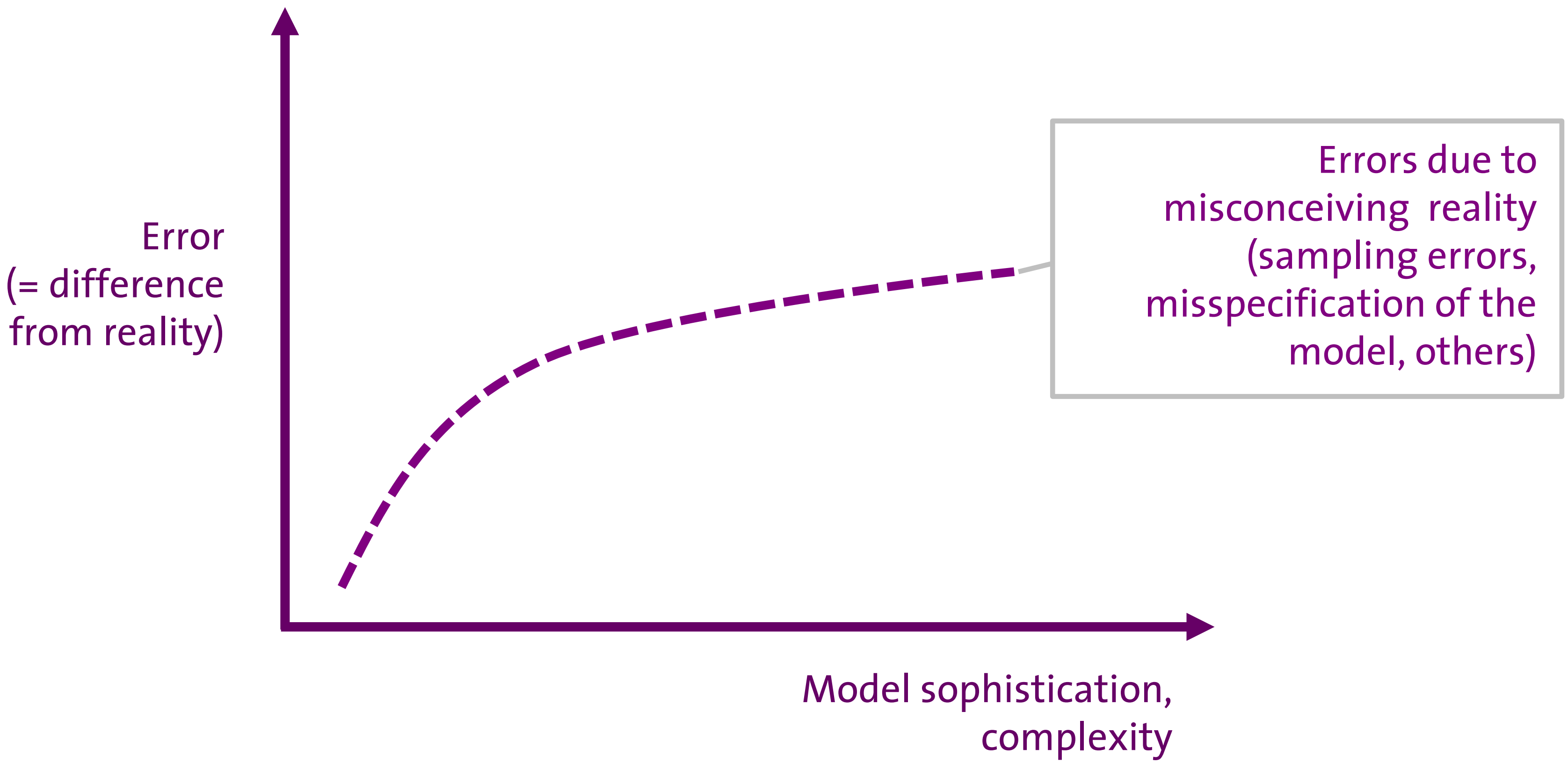
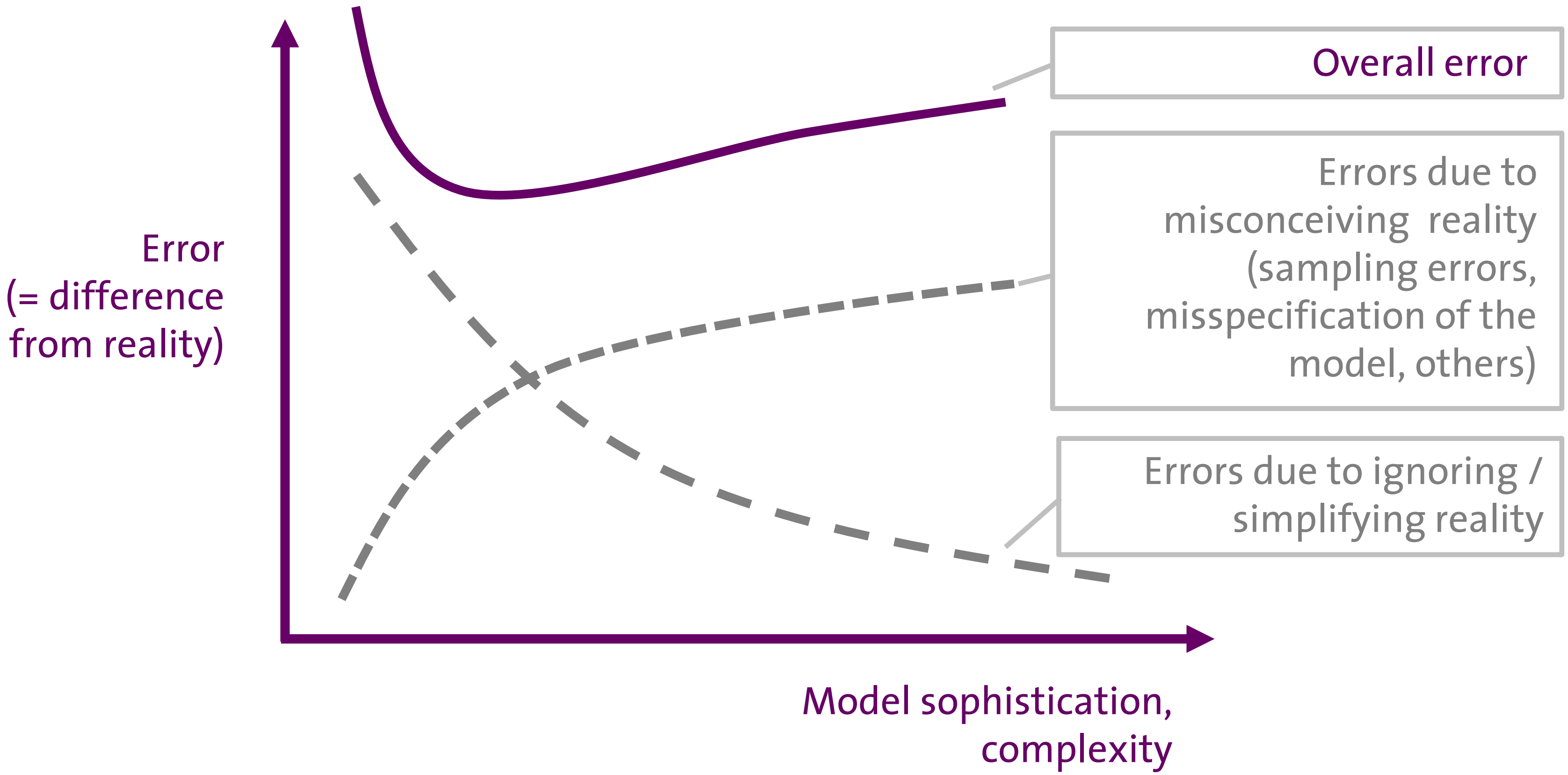
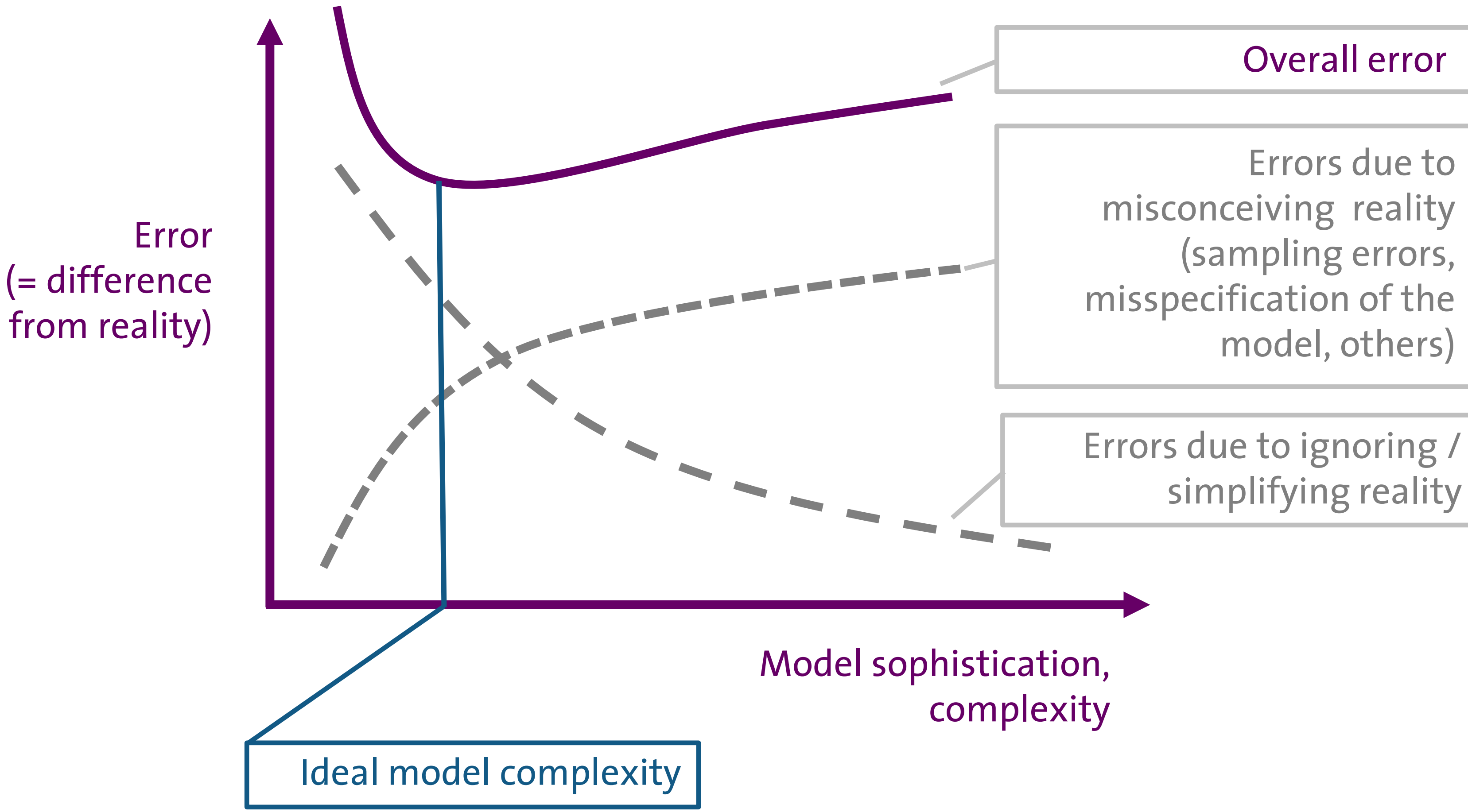
When does regionalised LCIA make sense?



When does regionalised LCIA make sense?



When does regionalised LCIA make sense?



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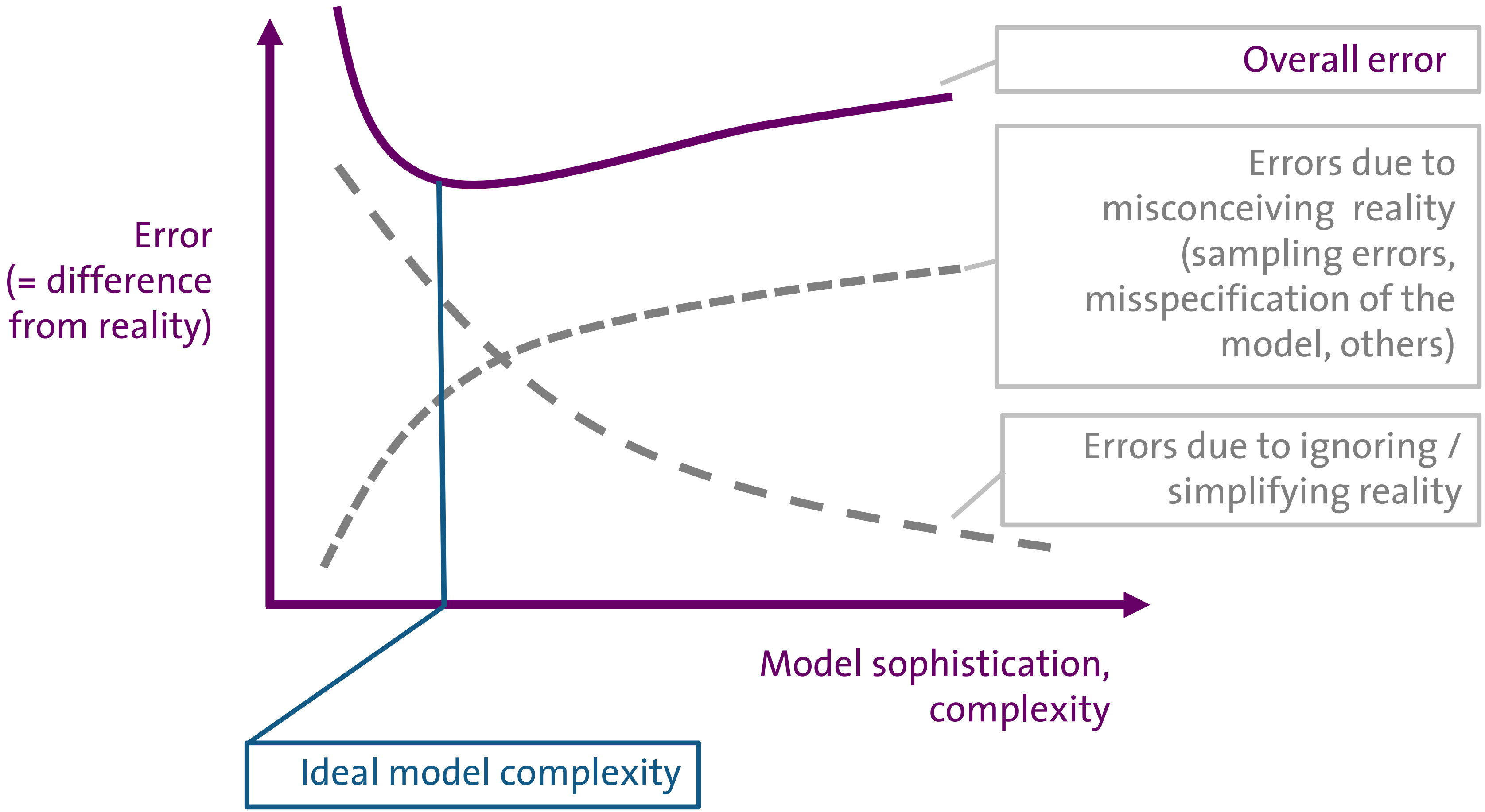
When does regionalised LCIA make sense?



source: SRU, Umweltgutachten 1974, Stuttgart 1974, p. 208; Ciroth, A.: Uncertainties in Life Cycle Assessment, editorial, Int J LCA 2004

Pragmatic approach

- In a pragmatic view, a regionalised LCIA makes sense in the following cases
  a. Large regional differences in impacts of the same elementary flow; this is impact category-specific (climate change – noise, toxicity, water)
  b. Low errors / “easy” implementation of the regional differences in impacts in the LCIA model,
  c. Low error in the specification of the regionalised inventory (for GWP, CH can always be used as a location..)
  d. Relevance of these regional differences especially for the specific decision case,

→ The effort for creating the models, applying the models and collecting suitable inventory information needs to be considered.

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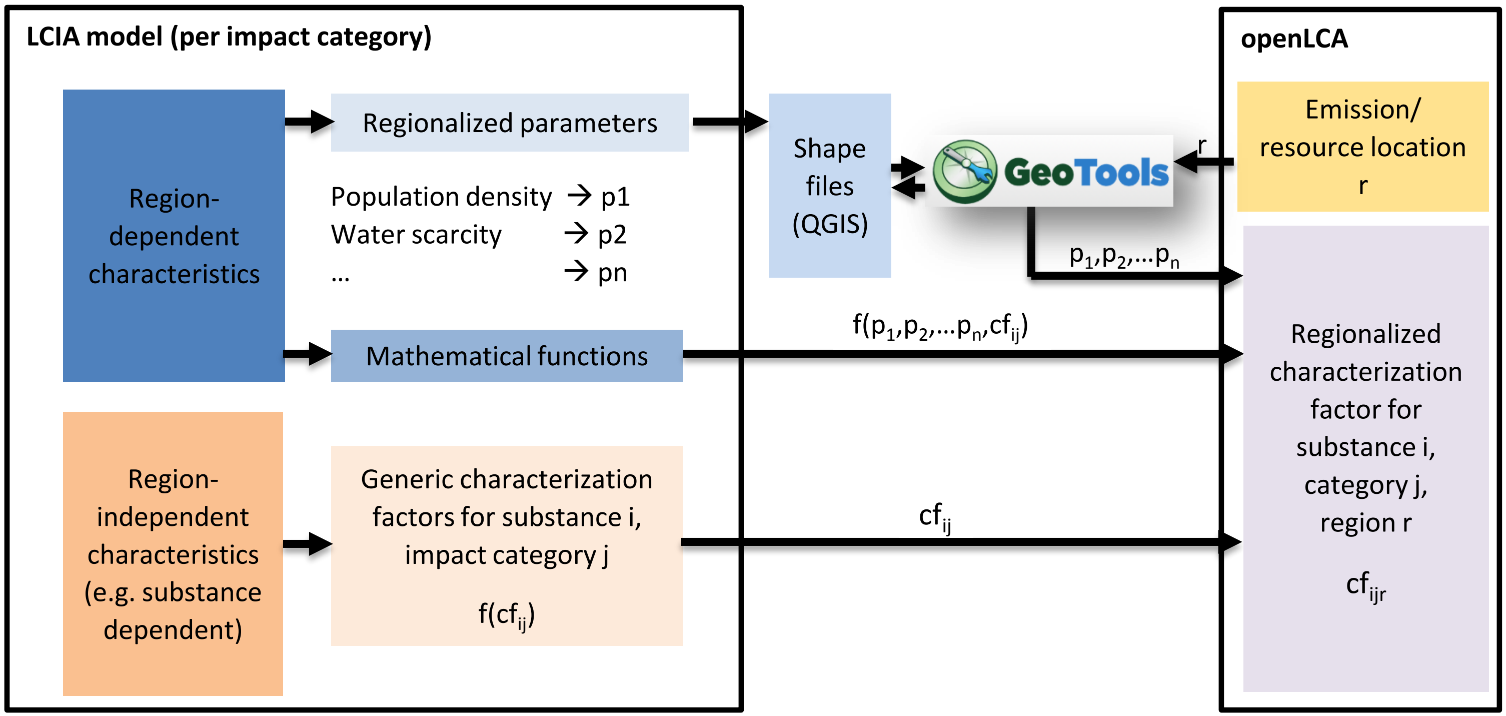
Regionalised LCIA methods in openLCA

- Idea:
  →Parameterization of LCIA methods



Parameterization of LCIA methods

- Formulas for calculating the characterisation factors (CFs) can be defined
  - Input and dependent parameters can be used as in the

Impact factors

Impact category: Land use

Flow	Category	Flow property	Unit	Factor	Uncertainty
Occupation, arable	resource/land	Area*time	m2*a	(0.60*ratio_biom)/SA_CF	lognormal: gmean=1.36 g...
Occupation, construction site	resource/land	Area*time	m2*a	(0.44*ratio_biom)/SA_CF	lognormal: gmean=1.00 g...
Occupation, forest, intensive	resource/land	Area*time	m2*a	(0.04*ratio_biom)/SA_CF	lognormal: gmean=9.09E-...
Occupation, forest, intensive, clear-c...	resource/land	Area*time	m2*a	(0.18*ratio_biom)/SA_CF	lognormal: gmean=0.41 g...

Parameters

Global parameters

Input parameters

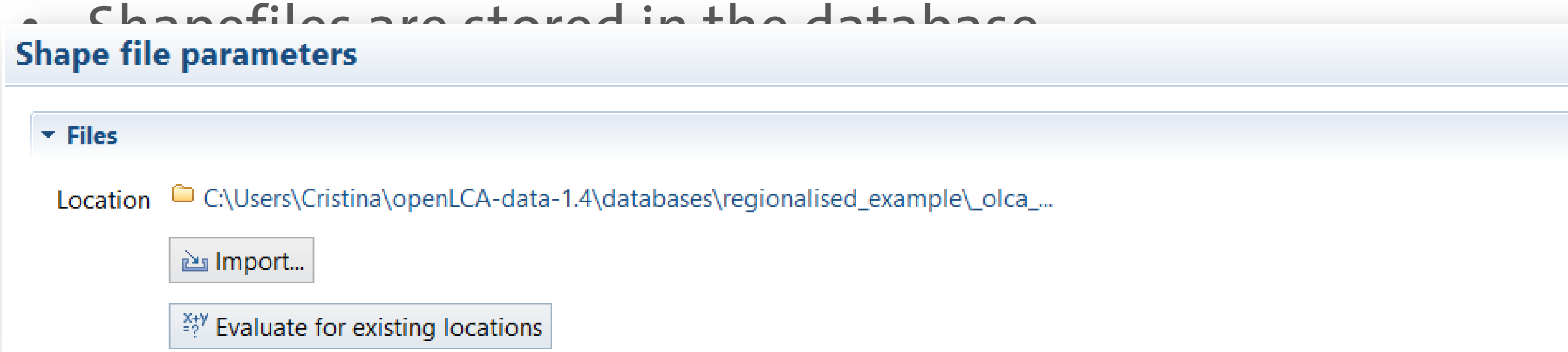
Name	Value	Uncertainty	Description
ratio_biom	1.0	uniform: min=0.21 max=1.97	from shapefile: ecoregions_with_biome_ratio
SA_CF	0.44	none	Settlement Area Characterization Factor
SA_EF	300.0	none	Settlement Area Ecofactor

Shapefiles containing regional characteristics

- Regional characteristics affecting the CFs can be defined with parameters:

  e.g. population density, precipitation variability,etc.

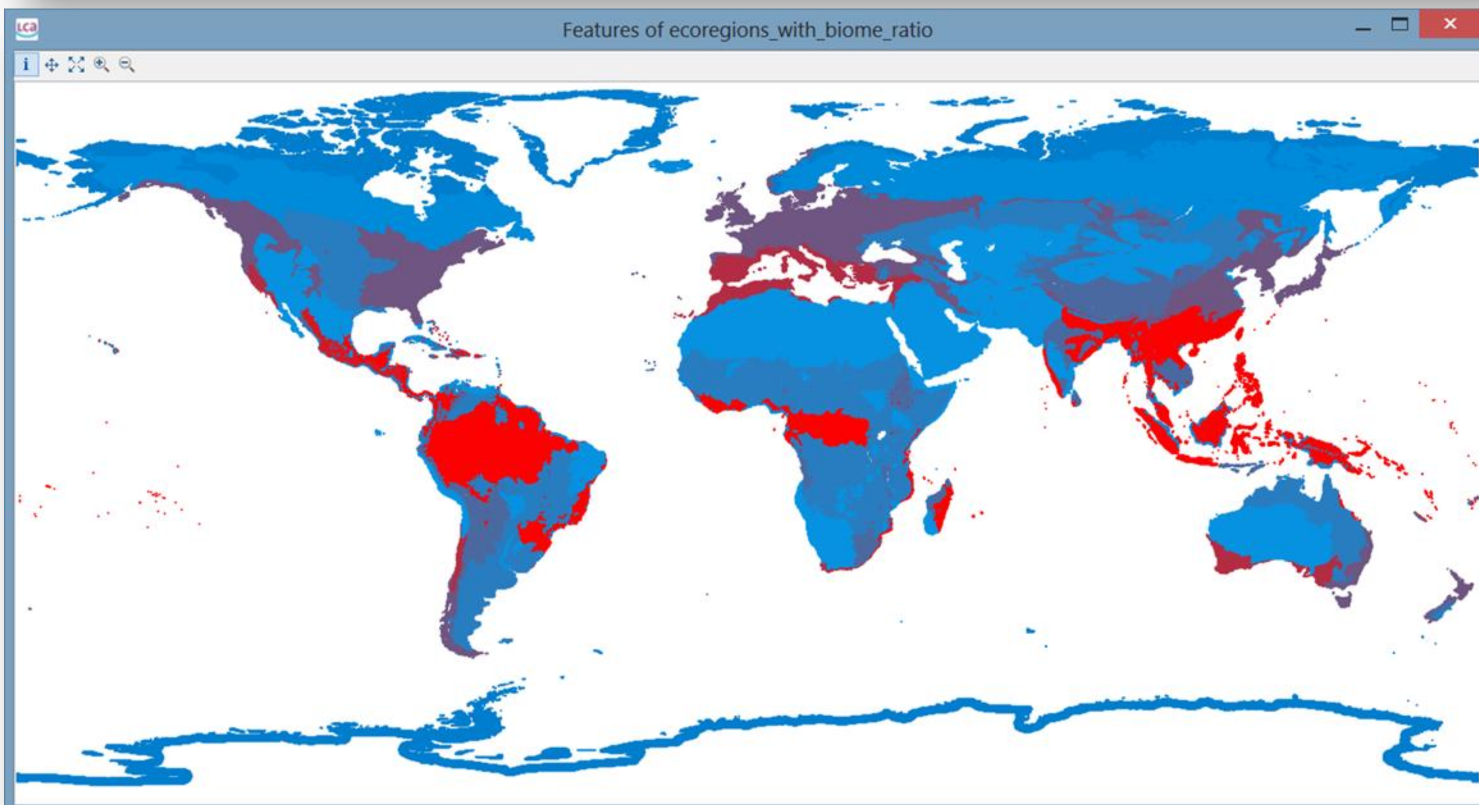
- Data for those characteristics is contained in shapefiles, which can be imported to openLCA
- Parameters are extracted during the shapefile import
- Shapefiles are stored in the database



Shapefiles containing regional characteristics

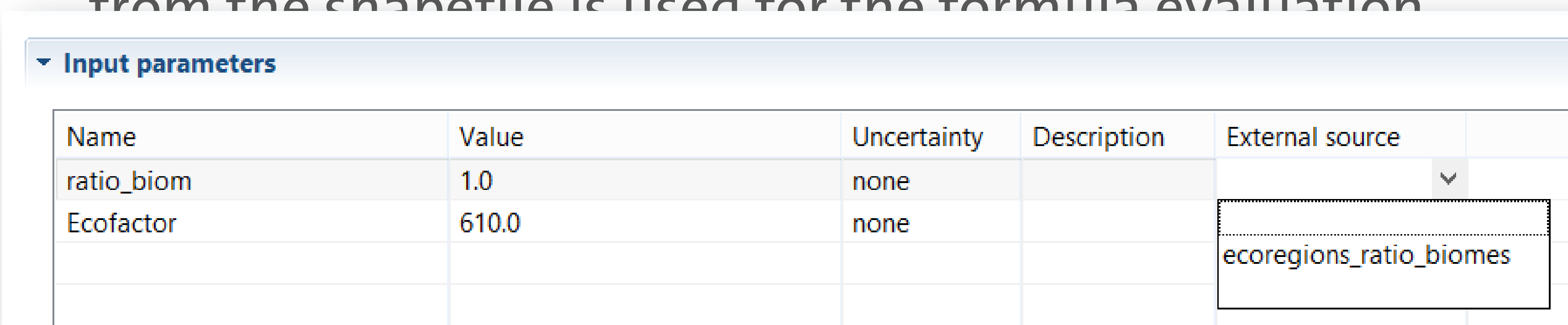
Parameters of ecoregions_with_biome_ratio

Name	Minimum	Maximum
CLS_CODE	0.0	1144.0
ECO_ID_U	10000.0	17109.0
ECO_NUM	1.0	99.0
ratio_biom	0.20929077	1.96750671



Binding shapefiles and LCIA method parameters

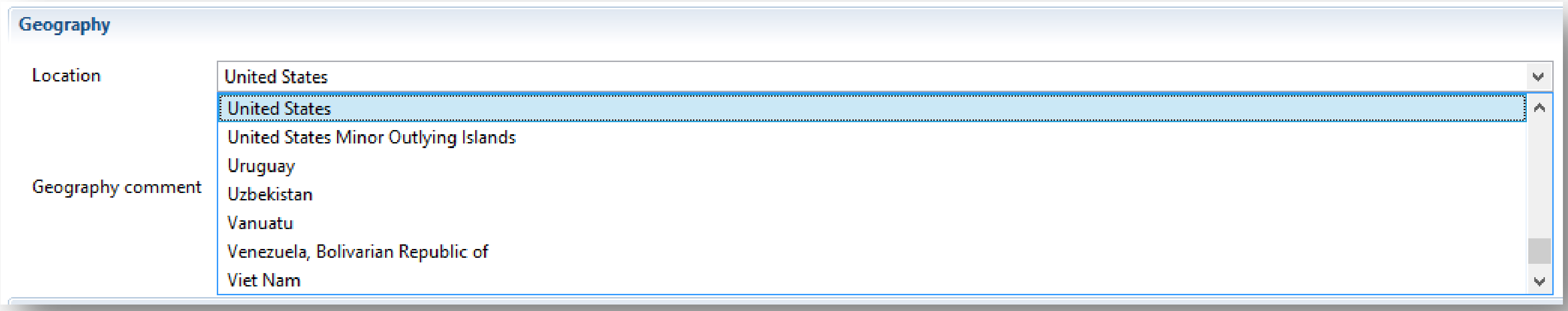
- Parameters of shapefiles can be bound to input parameters
- Default value of parameters is used for normal calculations and formula evaluation
- In regionalized assessment the parameter value derived from the shapefile is used for the formula evaluation



Extension of locations in openLCA (I)

Traditional approach:

- A list of locations available under File/Preferences/Locations.
- The geographic information of the locations was limited to a pair of latitude, longitude data.
- The processes could only used locations from the pre-defined list.

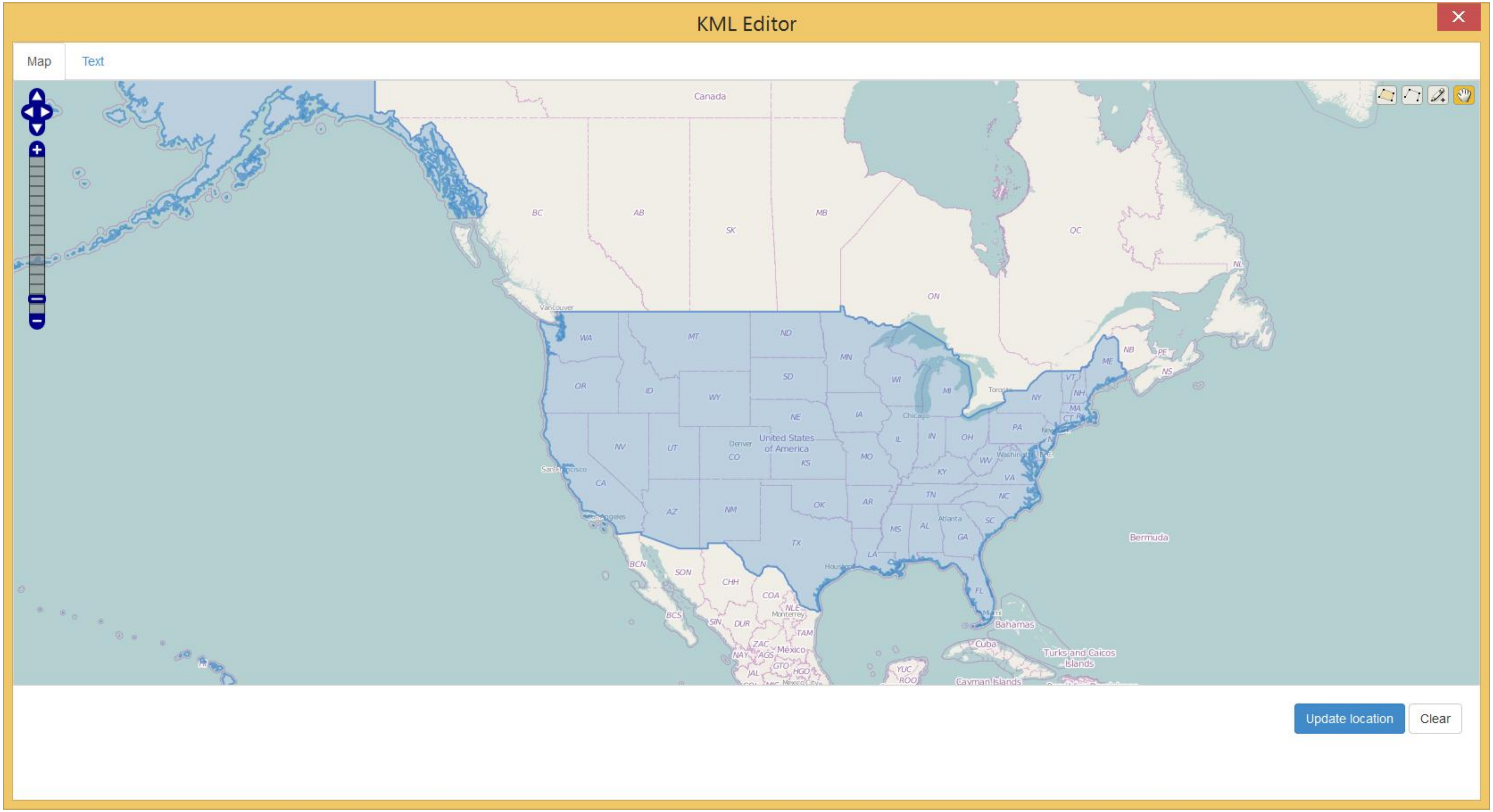


Extension of locations in openLCA (II)

New approach:

- The list of locations available in the database is shown in File/Edit locations.
- KML data can be added to each location (polygons, lines, points):
  - Import of kmz/xml files with geographic data.
  - Write the coordinates in the "Text editor".

Extension of locations: KML editor (map)



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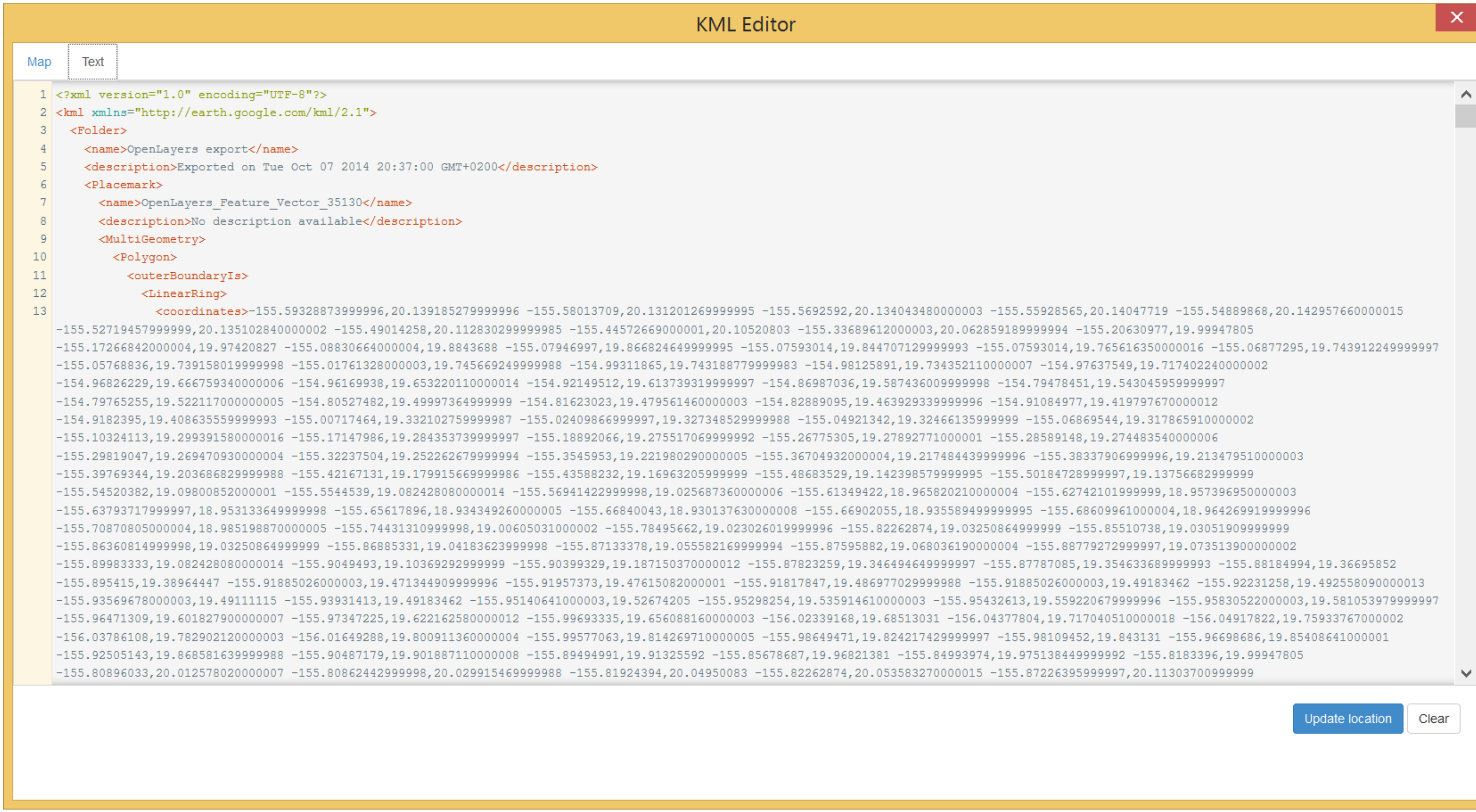
Extension of locations: KML editor (text)



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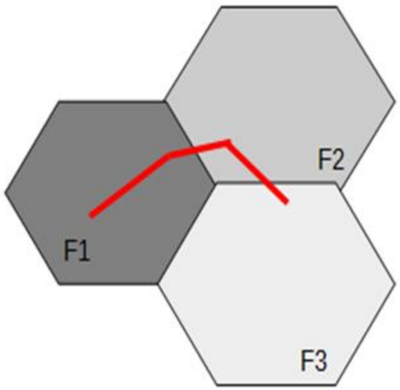
Calculation framework

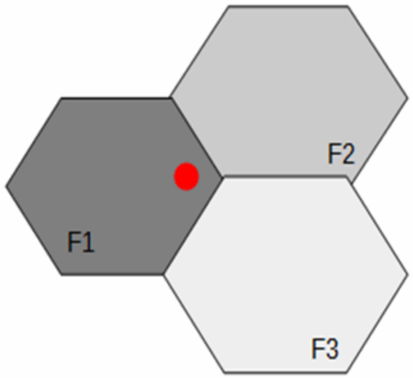
Linking of process locations and LCIA methods spatial units

- GeoTools libraries integrated in openLCA
  - The intersection between shapefiles features and process geometries is calculated.

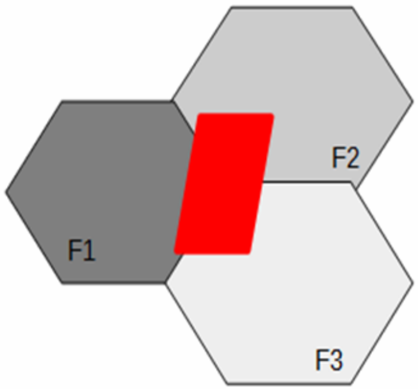
→A weighted mean calculated for each regional parameter



(p(F1)*L(F1) + p(F2)*L(F2) ...) /L



p(F1)



(p(F1)*A(F1) + p(F2)*A(F2) ...) /A

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Calculation framework

Regionalised LCIA calculation:

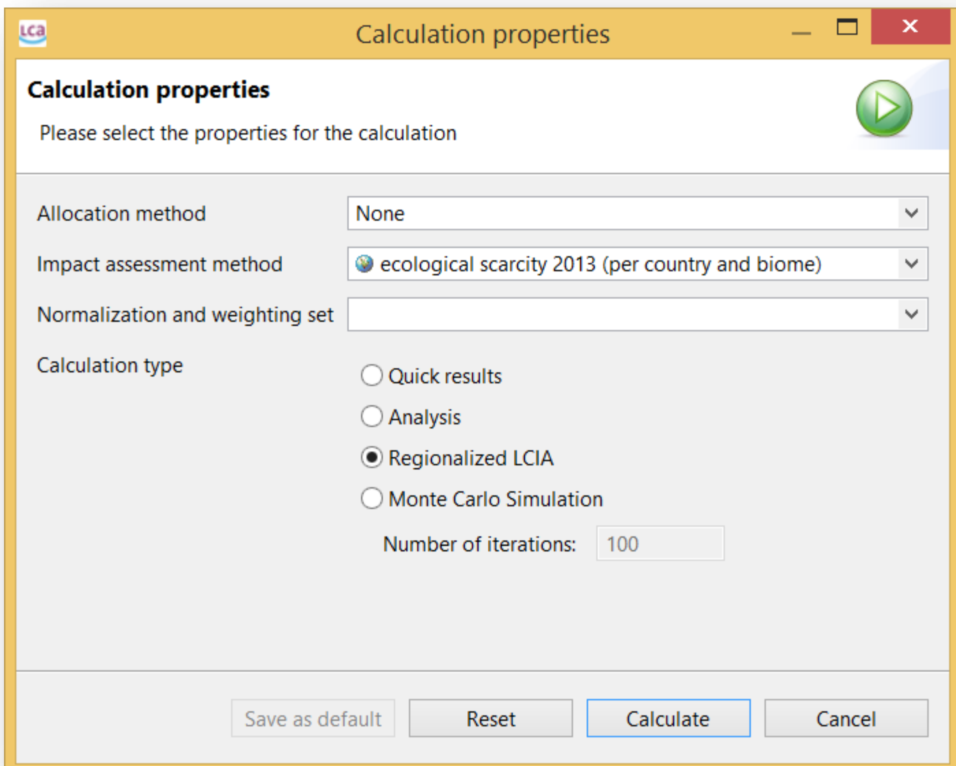
- Creation of a regionalised result matrix for the inventory (GR)
- Creation of a regionalised LCIA matrix (CR)
- Creation of the regionalised LCIA result (RR)

$$RR = CR * GR$$

Regionalised LCIA: Calculation procedure

- Select the “Regionalised LCIA” option in the calculation properties window:

→ The impact method select must contain regionalised impact factors



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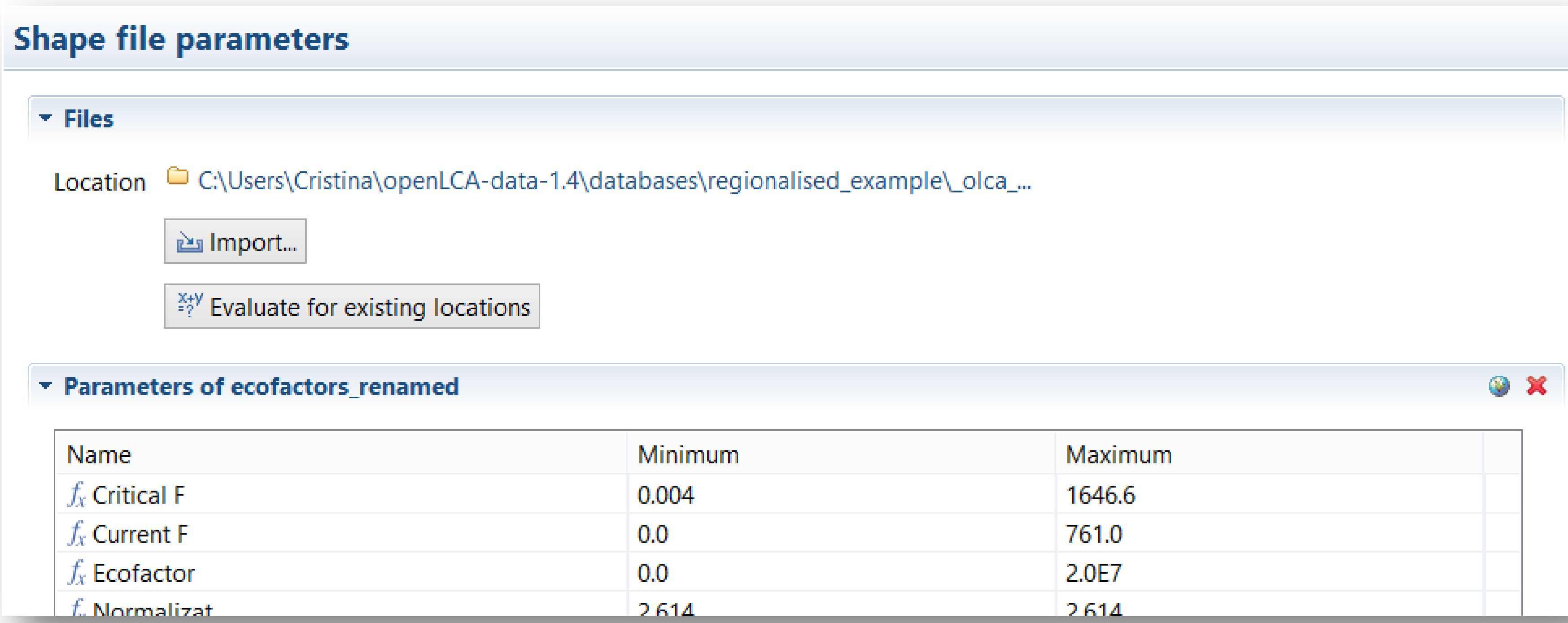
Regionalised LCIA: Calculation procedure

- To reduce the calculation time for complex systems, it is recommended to evaluate the intersections with the existing database locations when the impact method is defined:



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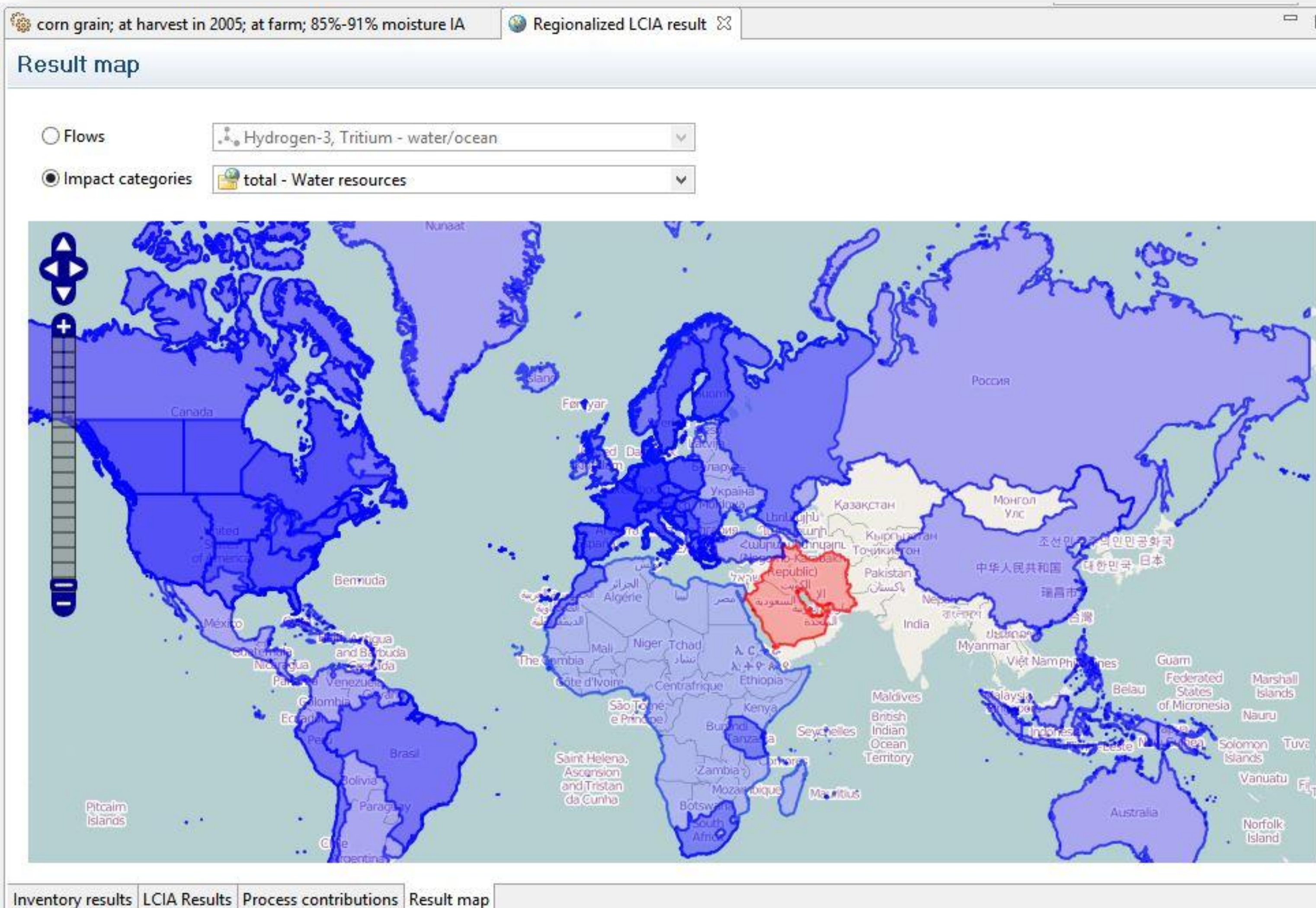
Regionalised LCIA: Results (I)



Regionalised LCIA: Results (II)

Locations

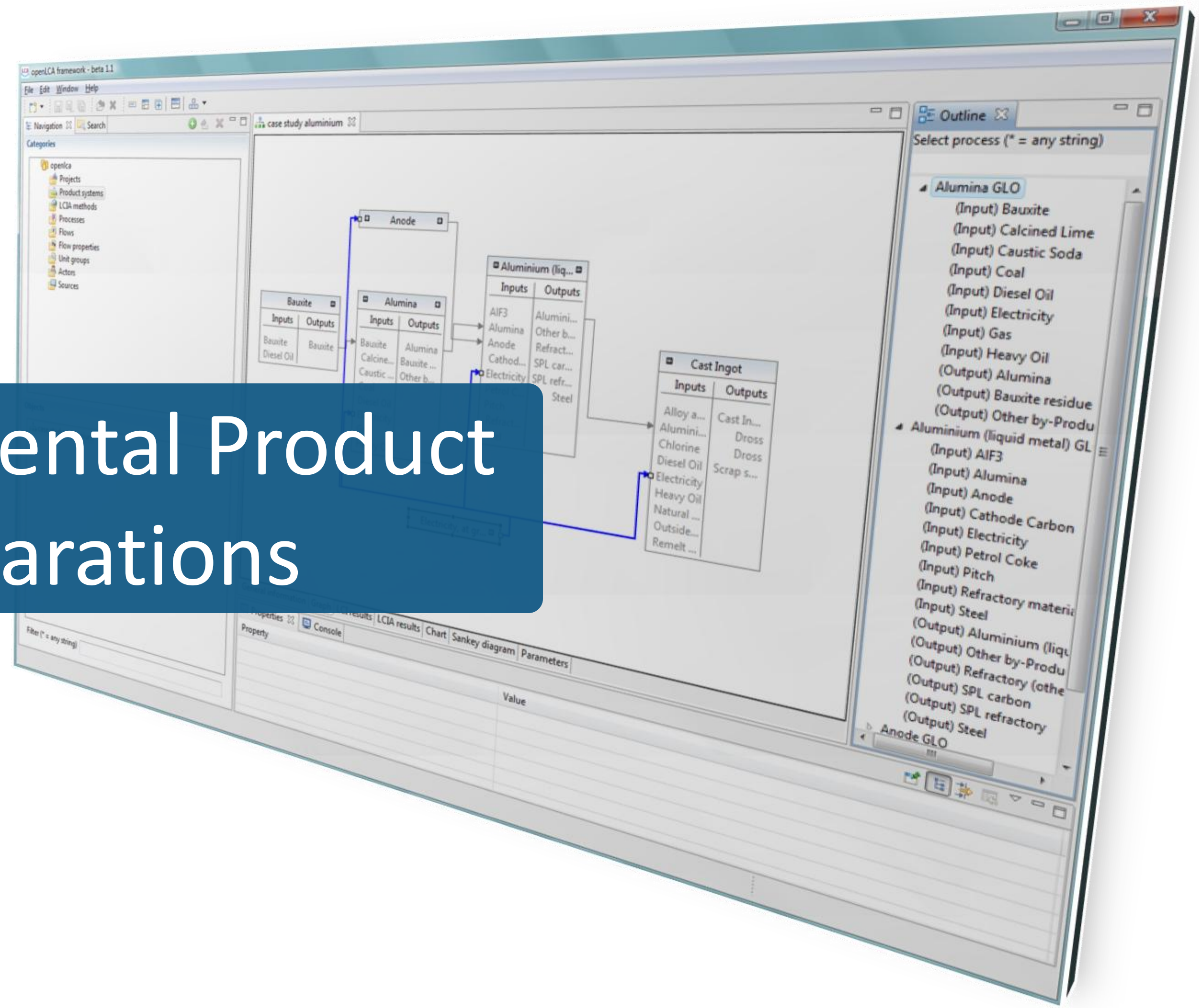
- (•) Flows: Manganese - air/low population density
- ( ) Impact categories: total - Water resources

Result contributions

Location	Process	Amount	Unit
Latin America and the Caribbean		1.79256E-9	kg
	copper, primary, at refinery	1.79256E-9	kg
	copper concentrate, at beneficiation	3.21146E-10	kg
	hard coal, at mine	3.21146E-10	kg
	hard coal, at regional storage	3.21146E-10	kg
Europe		4.06805E-10	kg
Global		2.99522E-10	kg
Indonesia		2.83524E-10	kg
Germany		7.65524E-11	kg
Poland		5.91038E-11	kg
Spain		2.05723E-11	kg
	lignite, burned in power plant	2.05723E-11	kg
	natural gas, burned in power plant	2.05723E-11	kg
	electricity, production mix ES	2.05723E-11	kg
	hard coal, burned in power plant	2.03072E-11	kg
	electricity, natural gas, at power plant	2.03072E-11	kg

Inventory results | LCIA Results | Process contributions | Result map | Locations

Environmental Product Declarations



Environmental labeling according to ISO

	Type I Environmental labeling	**Type II** Self-declared environmental claims	**Type III** Environmental declarations
Information	Qualitative	Qualitative / quantitative	Quantitative
Range	Special products	All products and services	All products and services
Quality check	Verification of eco-labeling body	None	Third-party certification
Receiver	Consumers	Consumers/ professional purchasers	Professional purchasers

http://www.dantes.info/Tools&Methods/Environmentalinformation/othertools_label.html

Environmental Product Declaration (EPD)

- A declaration based on Life Cycle Assessment
- A verified document that reports environmental data of products based on life cycle assessment (LCA) in accordance with the international standard ISO 14025 (Type III Environmental Declarations)
- According to EN 15804:2012, an EPD

  > “communicates verifiable, accurate, non-misleading environmental information for products and their applications, thereby supporting scientifically based, fair choices and stimulating the potential for market-driven continuous environmental improvement”

- The information may cover different life cycle phases.

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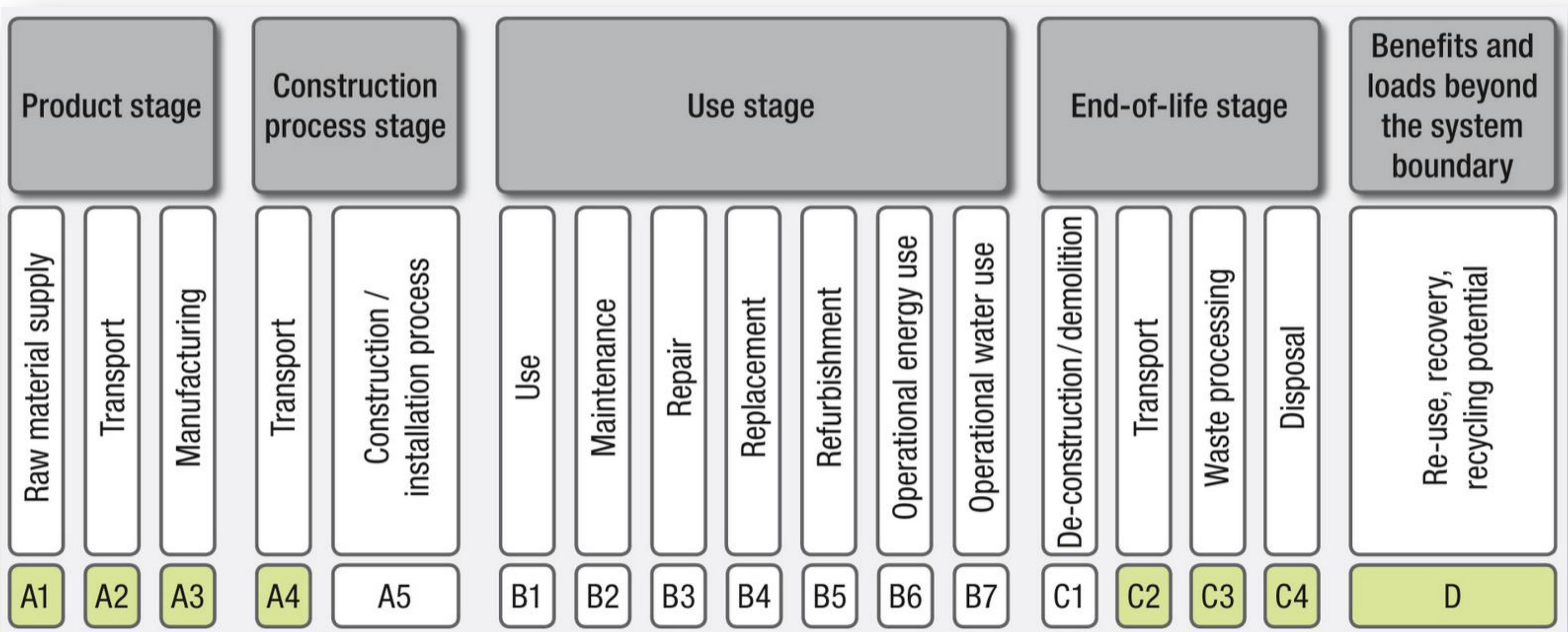
What is the EN 15804 for?

- To ensure that the EPDs of construction products are derived, verified and presented in a harmonized way
- EN 15804 compliant EPD can report performance against the indicators for 17 life cycle modules:



http://corporate.armacell.com/fileadmin/cms/corporate/en/press-room/press-releases/2013/2013-06-14-TA-Green-Building/Figure_9.jpg

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Thank you!

Contact

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