openLCA 1.4 overview and first steps

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1   Introduction

openLCA is the open source software for Life Cycle Assessment (LCA) and Sustainability Assessment, developed since 2007 by GreenDelta, www.greendelta.com. As open source software, it is freely available, e.g. from the project website, www.openlca.org, without license costs. Version 1.4 was released in June, 2014. This text focusses on this 1.4 version of openLCA, explains first steps in openLCA, including the installation, gives an overview of features, and shows how to migrate databases from the 1.3 version to the new version.

2   Installation

The installation of openLCA is slightly different for Window, Mac and Linux.

2.1   Installation, Windows

For windows, 64 bit and 32 bit versions are available; the following will focus on the 64 bit version. For the installation, you will need administrator rights. In a Windows environment, openLCA has the following hardware requirements:

- 4 GB RAM (32bit), 6 GB RAM (64 bit)
- 500 MB free hard disk space (depending on the databases that you want to use)

As usual in Windows installation, you can select whether openLCA should be used only by the user who installs (i.e. by you), or by anybody working on the computer.
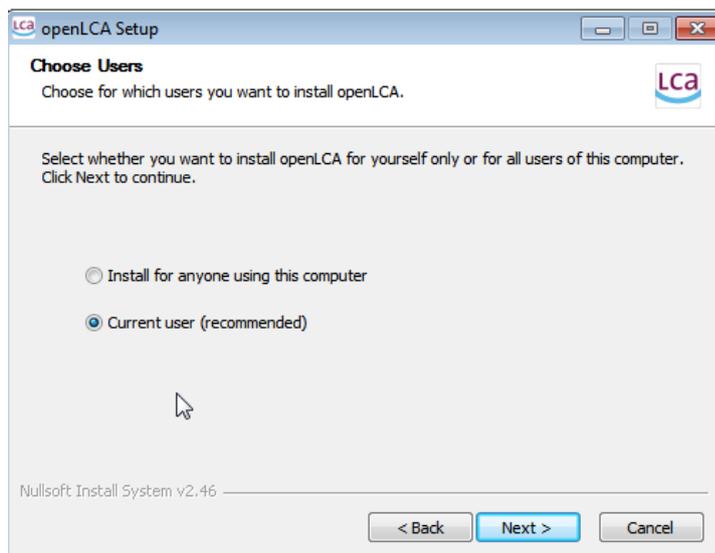
Figure 1: Setup screen

The following installation steps should be rather self-explanatory.

2.2   Installation, Mac

For Mac, a 64 bit version is available. In a Mac environment, openLCA has the following hardware requirements:

- 64 bit
- 500 MB free hard disk space (depending on the databases that you want to use)
- 6 GB RAM

The openLCA software requires Java in version 8; install Java before beginning with the openLCA installation (Java SE Development Kit for Mac OS available under http://www.oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html).
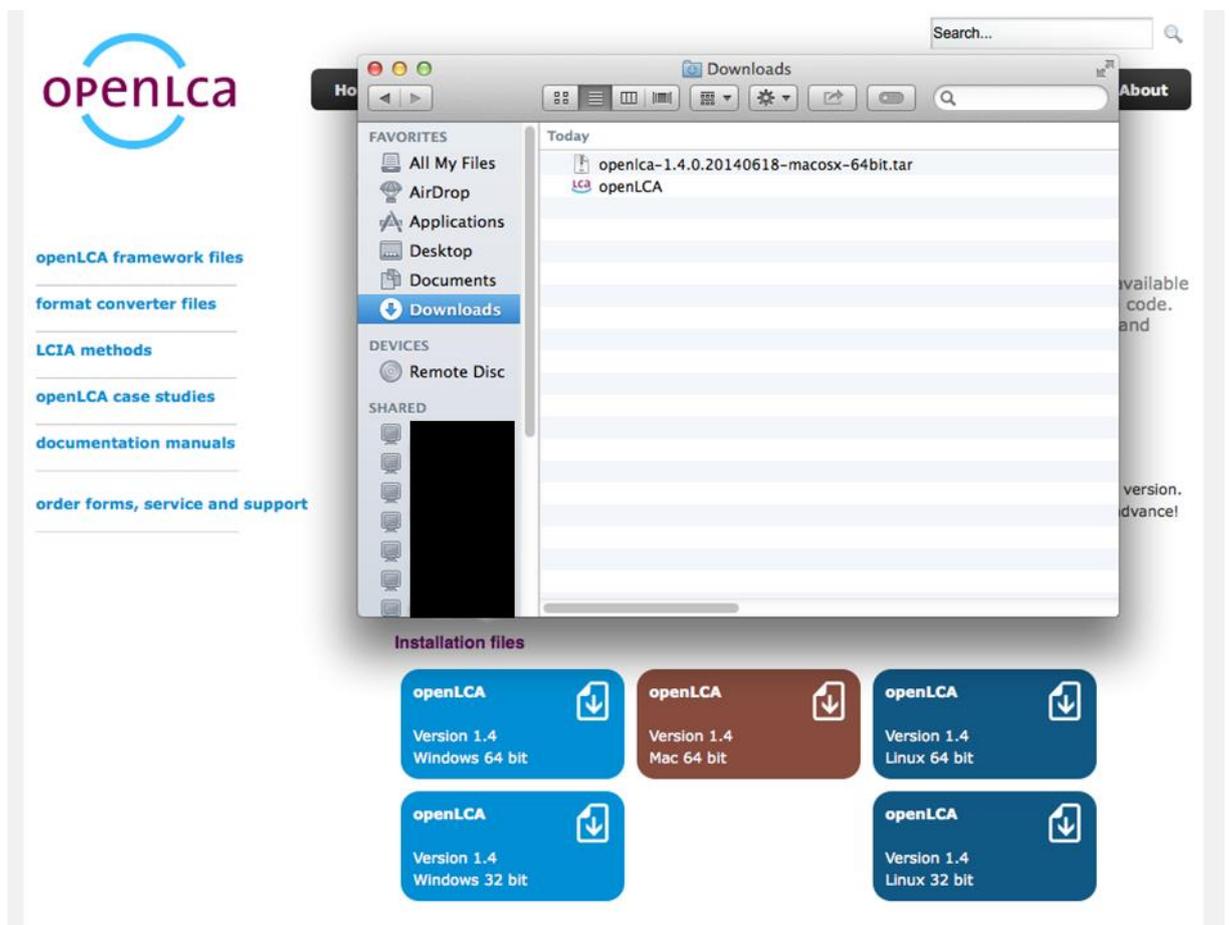
Figure 2: Installation file for Mac, downloaded from openLCA website

Download the installer file from openlca.org/downloads. Once the download is complete find the program in the "downloads" folder and transfer it into "applications". Double-click on the program to open it. A warning message will appear because the application was downloaded from the internet. Select "open". This message will only appear the first time you open the program.

2.3   First start

After the installation, you can start openLCA. Initially, openLCA does not contain any data, therefore the 'navigation' section on the left is empty.
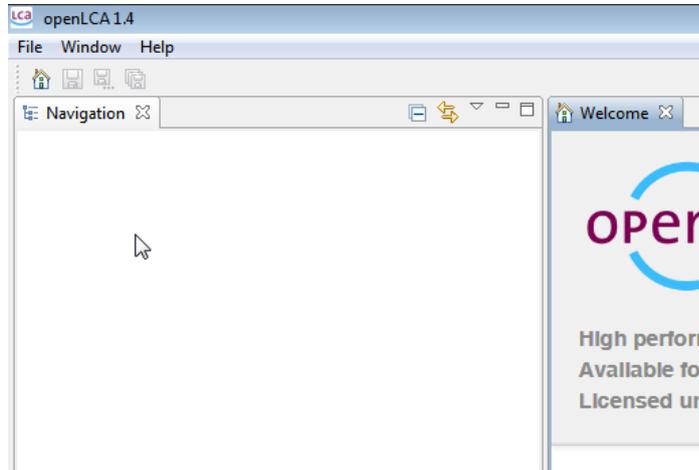
Figure 3: Initially empty navigation area in openLCA

To change this, you can either:

- Create a new, empty database; or
- Import an existing database.

2.3.1   *Creating a new, empty database*

With a right-click in the navigation area, you can create a new database.
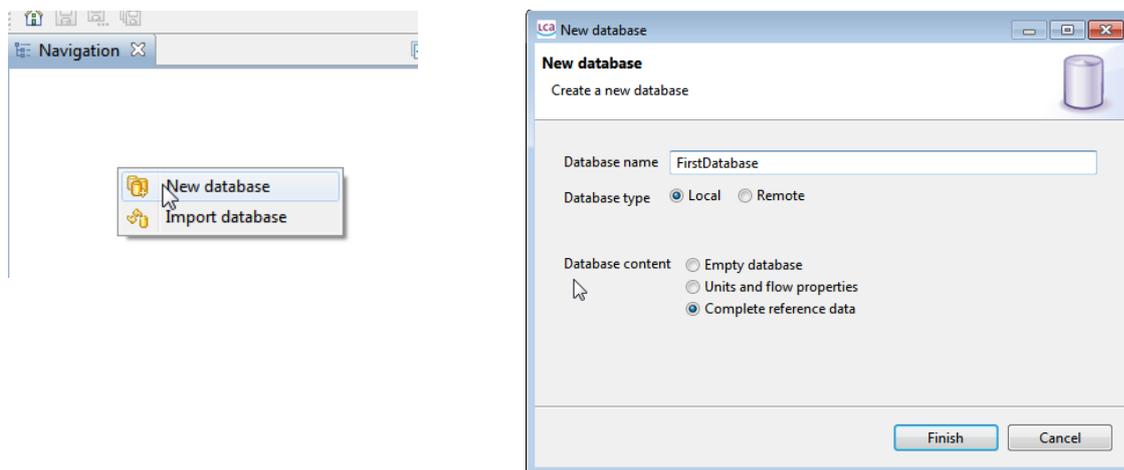
Figure 4: Database creation wizard

For the beginning, it is recommended to create the database with these settings: 'local database', and 'complete reference data'.

After a few seconds, you can have a look at the newly created database:
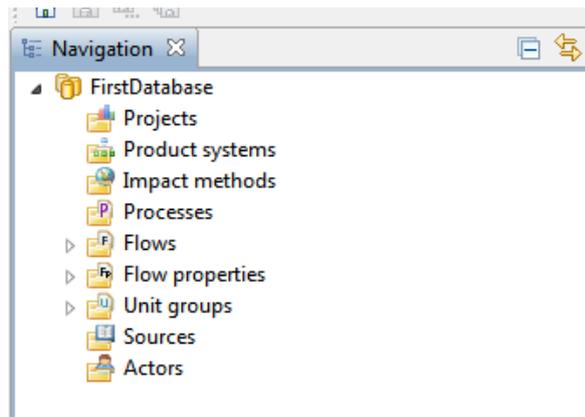
Figure 5: Created database with main navigation tree

These elements in the database will be familiar to you if you have worked with previous versions of openLCA. They will be explained in more detail in the next section.

'Reference data' are especially units and elementary flows. Since we have created the database with reference data, it contains flows and units, which can be seen under the respective categories.
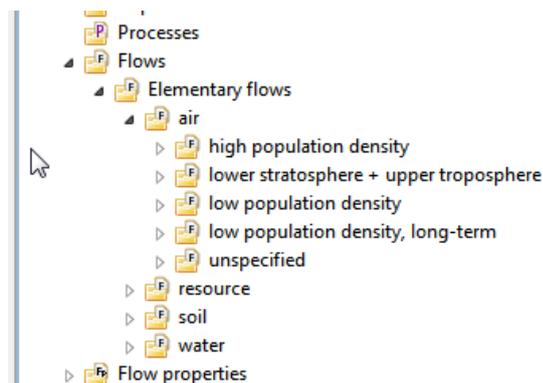

Figure 6: Reference flow categories in the database

The database does not contain any process data sets though, but you can start creating your own processes, using the flows and units that are already present.

2.3.2   Importing an existing database

As a second option, you can import an already existing database. The database can for example be a migrated openLCA 1.3 database (this is explained in section 4), or you can import a database downloaded from the openLCA nexus site, https://nexus.openlca.org/.

For example, we are downloading the ecoinvent 3 'cut-off' database from nexus[1].

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[1] Some of the databases in nexus are for purchase, e.g. the ecoinvent database.

openLCA

| | ecoinvent 3 - cut-off | 1 | openLCA 1.4 | Show details |

☑ I have read the licenses of the selected databases and accept them
☑ I have read the EULA and accept it
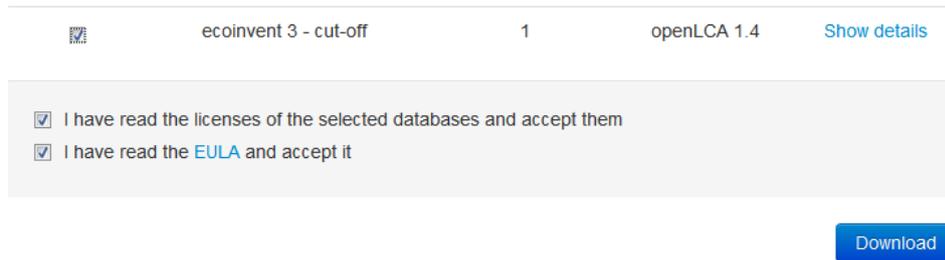
Download

Figure 7: downloading the ecoinvent cut-off database from nexus

In order to import the database, select 'import database' from the context menu …

Figure 8: Newly created ecoinvent database, with process data sets

2.3.3   LCIA methods

The databases in nexus do not contain LCIA methods ('impact methods', in the category tree). To add these, download the LCIA method pack from the openLCA download page (www.openlca.org/downloads).

openLCA

LCIA methods

LCIA method pack for openLCA nexus

A comprehensive package of environmental impact assessment methods for use with all different databases available in the nexus system - including ecoinvent 3, GaBi and ELCD. Includes normalisation and weighting as far as this is foreseen by the method. In addition, a pack containing a social LCIA method for use with the Social Hotspots Database is provided. Please observe the license* (Commons Attribution-ShareAlike 4.0 International) while using it. Please provide feedback - thanks in advance!

The environmental LCIA methods pack is available in several versions:

Database for openLCA 1.4 (zolca file, 15 MB), with normalisation and weighting factors.

Database for openLCA 1.3.4 (olca file, 19 MB), with normalisation and weighting factors.

EcoSpold01 (zip archive, 10MB) without normalisation values as the format does not allow this.

The social LCIA method is available in EcoSpold01 (zip archive, 64 kB).

We will import these now into the ecoinvent database, as follows:

Via File / Import we select 'database import':
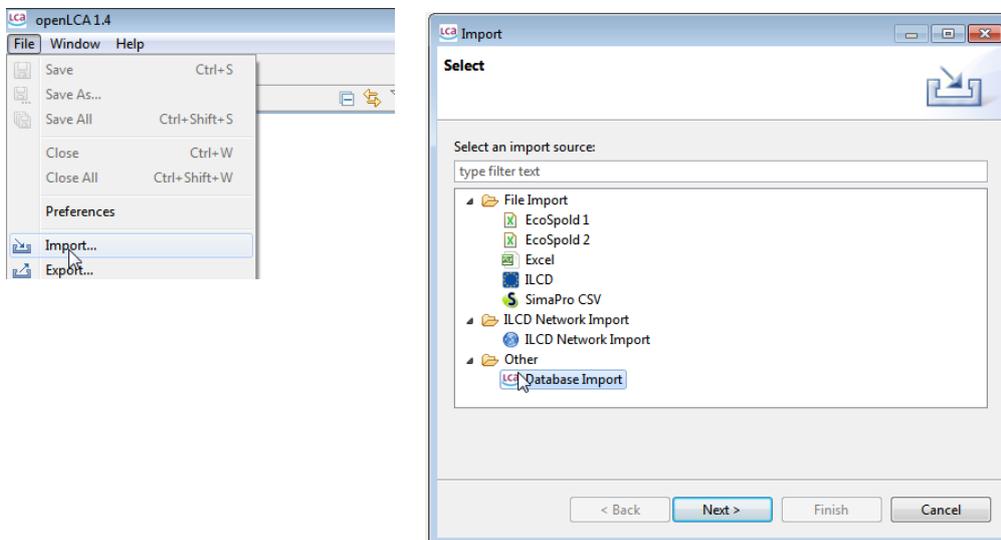
And then select 'from zolca file'.
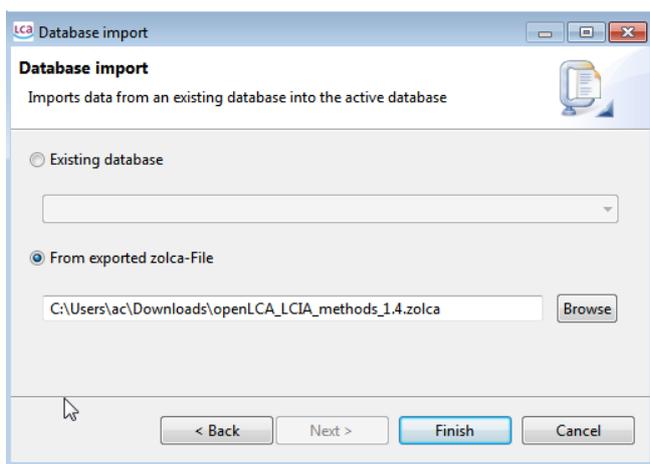
This import may take a few minutes. When it is finished, the LCIA methods are also available in the database.
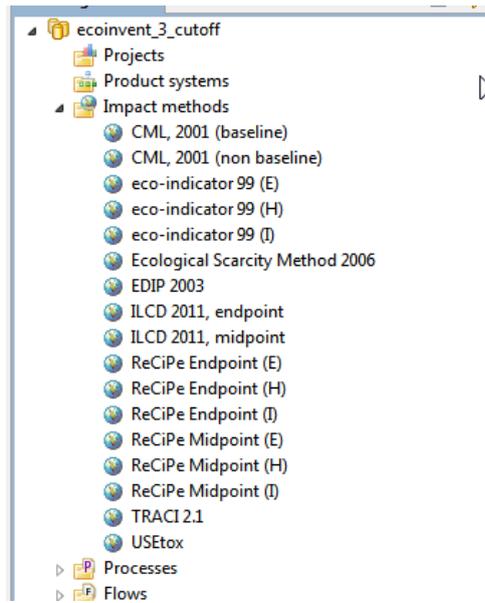
Figure 9: Newly created LCIA methods

3   LCA modelling in openLCA

Core of any LCA modelling is the modelling of the life cycle of the product under study. In openLCA (as in ISO 14040), the life cycle model of a product is called product system, and there are different ways for creating and completing product systems, depending on the database and user preferences.

3.1   Product system creation from a process data set

The first possibility is to create the product system from the process. Open a process data set, go to the page 'general information', and click on 'Create product system'.
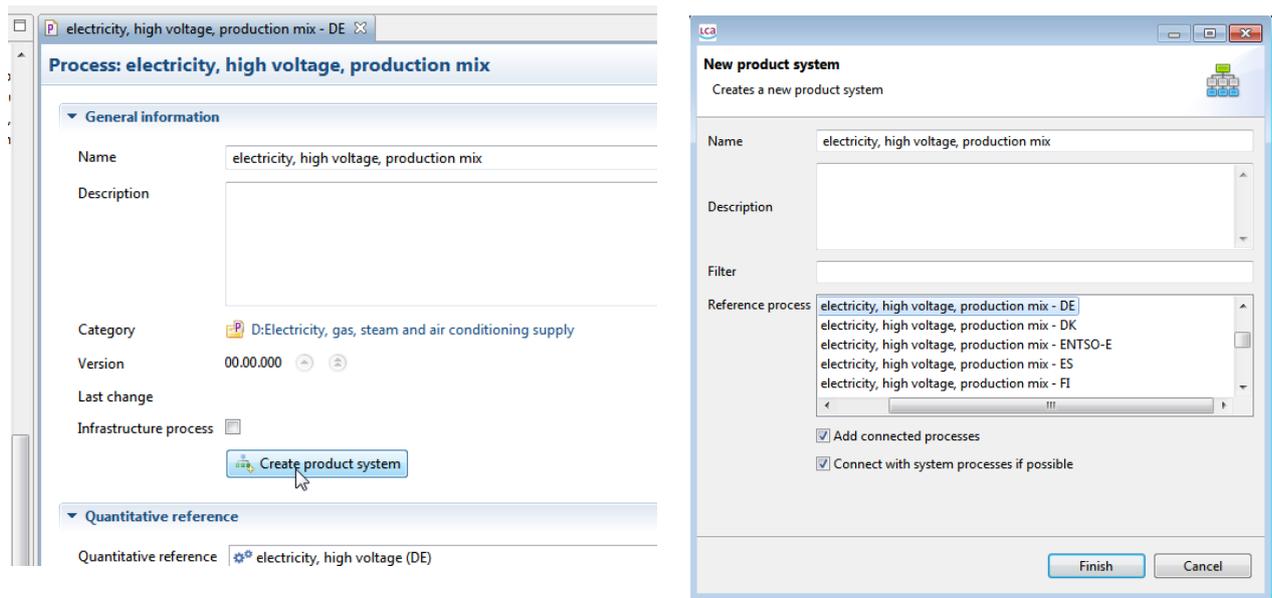
Figure 10: Product system creation wizard, here started from a process data set

Checking 'add connected processes' in the product system wizard will make openLCA connect those processes that have the same products, for the same locations, and where the units of the flows can be converted. For many databases, such as the ecoinvent database, these criteria clearly identify the delivering process; however, usually the default provider processes are specified, for the inputs of processes (check the sheet inputs/outputs for processes).

Figure 11: Default provider: electricity production, in the process data set inputs/outputs

The model graph in the product system shows the connected processes. These connections can be edited (deleted, expanded for new product providers) and processes can be entirely deleted from the product system if they have no connections in the life cycle any more.

Figure 12: The model graph of a product system showing some few connected processes. The menu on the right is available via a right-click

Clicking on 'calculate' in the product system general information tab calculates the life cycle; you can select an LCIA method and a normalisation set if available and relevant. You can further choose between quick results and an analysis which provides more detailed results.

Figure 13: Different options for the calculation of a product system

The results are provided in several sheets, which are often self-explanatory.

Figure 14: Sheet 'process contribution' (cropped) as an example for product system analysis results
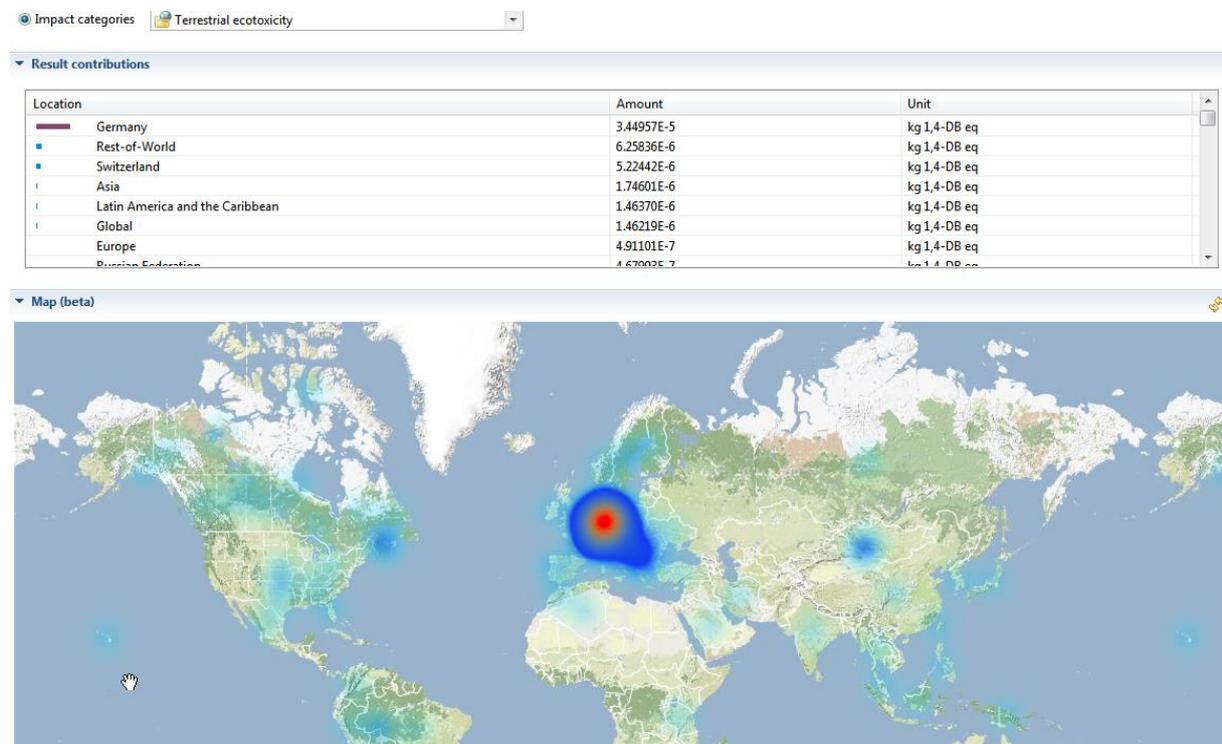

Figure 15: Sheet 'locations' (cropped) as an example for product system analysis results

3.2   Product system creation as new product system

As a second option, a product system can also be created from the product systems category:
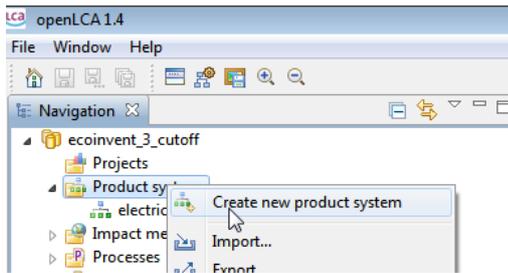
In addition to the creation of a product system from a process data set, a reference process needs to be selected here. By entering text into the "Filter" field, you can narrow down the selection which helps to identify the suitable process.
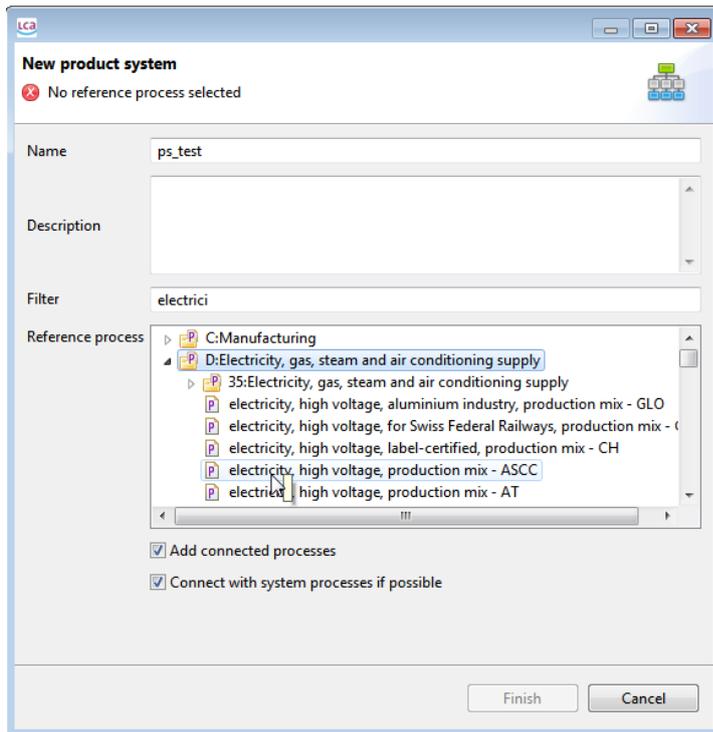
Figure 16: Second possibility for product system creation: as a new product system, not starting directly from a process data set. The reference process needs to be selected, the available processes can be filtered

3.3   Manually connecting processes

As an alternative to the automatic connection of processes, you can also manually connect processes in the model graph of a product system. Right-click on the process, then selecting 'build supply chain', offers both building the complete chain for the process, or only the next tier.

4   Migrating data and models from openLCA 1.3

Via a plugin that is available for the 1.3.4 version of openLCA, you can migrate complete databases from 1.3.4 "olca" format into the new "zolca" format.

The plugin is directly available in the openLCA plugin manager of openLCA 1.3.
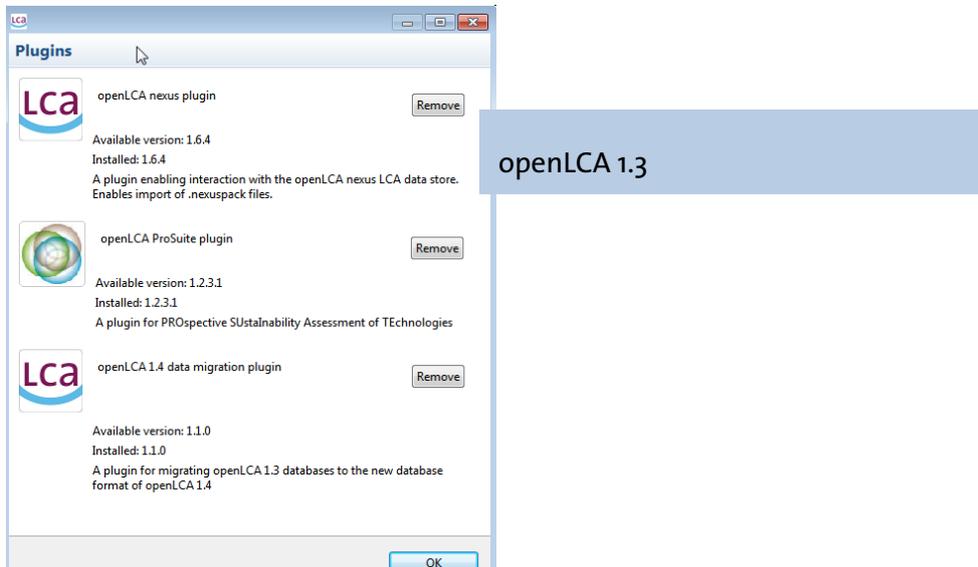
Figure 19: Plugin manager in openLCA 1.3.4: data migration plugin

If it is installed (in openLCA 1.3), you can export an existing database via the export wizard...
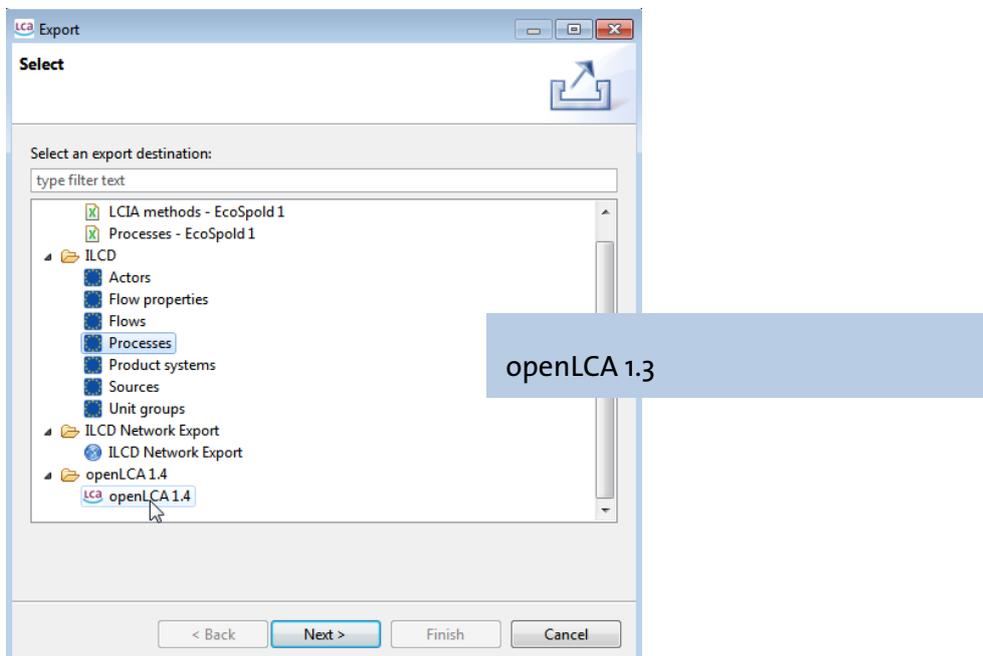
Figure 20: Export option in openLCA 1.3.4 with installed data migration plugin: openLCA 1.4 database

... to a database in the 1.4 "zolca" format, which, in turn, can be imported into openLCA 1.4 via the import wizard of openLCA 1.4
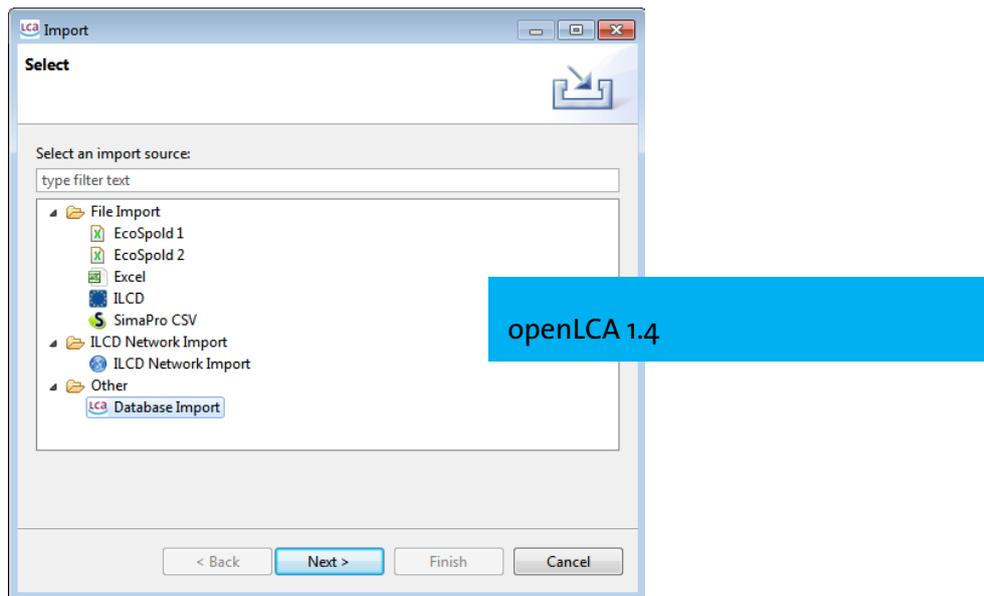
Figure 21: Database import in openLCA 1.4 in the import wizard

The database will then be imported and be available as one new, additional database in openLCA.
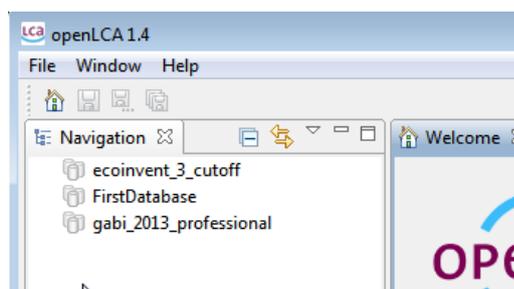
Figure 22: After the import, the database is available in openLCA

In some (IT) environments, users may be prevented from installing the plugin – if this is the case for you, you can manually download the plugin from https://nexus.openlca.org/updatesite/plugins/org.openlca.xolca.db.upgrade_1.3.0.jar. Shut down openLCA, and then copy the plugin in the "dropins" folder of the openLCA installation which is usually located in a Windows system at [user_name]/AppData/Local/openLCA. The location can be modified during the installation procedure.
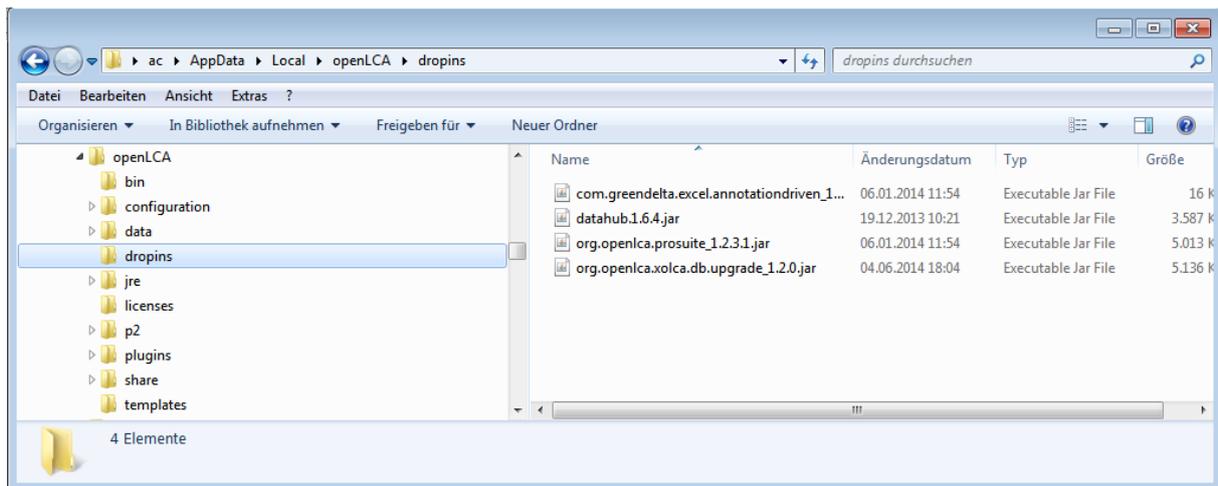
Figure 23: Dropins folder where the plugins are located

Then, restart openLCA and the plugin will be extracted and can be used afterwards.

> Note: If you want to use both version of openLCA on the same computer, we recommend you use the zip files for openLCA 1.4. They only need to be extracted; openLCA starts with a double click on openlca.exe. Thereby you can have the 1.3 version and the 1.4 version in parallel on the same computer. The data folder is different though, openLCA-data for openLCA 1.3 and openLCA1.4-data for openLCA 1.4. This ensures you can use all databases in parallel.

5 Quality assurance and performance

5.1 Quality assurance

In the development of openLCA 1.4, extensive tests have been performed to verify and validate the software algorithms and overall usage, also by external testers, e.g. by our Italian partner, be-LCA, www.be-LCA.com.

Tests have been performed for example to check

- openLCA results versus SimaPro calculation results
- openLCA results versus ecoinvent system process results

Further, 'constructed' use cases have been used to reflect specific modelling aspects of LCA (allocation, system expansion, uncertainty calculation, parameter usage, …) which have been calculated in other software systems, including Matlab / Scilab and excel.

Evidently, here is not the space to fully explain all the tests; as an example, a comparison of results some selected results obtained in SimaPro 8.0.3 Multi User Developer and openLCA 1.4 might suffice. More information is available on request (see contact information, below).

Figure 24 shows a comparison of inventory results for SimaPro and openLCA, for process electricity production mix high voltage, country mix, BE, for ecoinvent 3.0.1, default allocation model. Only those flows are considered where flow names and compartments are identical between SimaPro and openLCA, which is the case for more than 700 flows for the said system. The models have been calculated in both software systems, and then exported from SimaPro via text export (which is limited to exponent and two digits) and from openLCA via excel export.

As the figure shows, results are very similar. The most extreme ratios are still very close to 1 meaning that both software systems calculate almost fully identical results:

Top 5 minimum ratios are shown in table 1; table 2 shows the top 5 maximum ratios.

Table 1: Ratio of results from SimaPro and openLCA in a calculation comparison, 5 lowest

Input	Category	Sub-category	Flow_name	ratio_SP_to_openLCA
ja	resource	land	Transformation, to unknown	0.999999629
ja	resource	land	Transformation, from mineral extraction site	0.999999816
nein	soil	agricultural	Carbaryl	0.999999946
nein	air	high population den	Ethane	0.99999995
nein	soil	agricultural	Nicosulfuron	0.999999953

Table 2: Ratio of results from SimaPro and openLCA in a calculation comparison, 5 highest

| Input	Category	Sub-category	Flow_name	ratio_SP_to_openLCA
ja	resource	in ground	Gallium	1.000001574
ja	resource	land	Transformation, to forest	1.000001739
ja	resource	land	Transformation, to shrub land, sclerophyllous	1.000001744
ja	resource	land	Transformation, from dump site, inert materia	1.000003167
ja	resource	land	Transformation, to dump site, inert material la	1.000003167
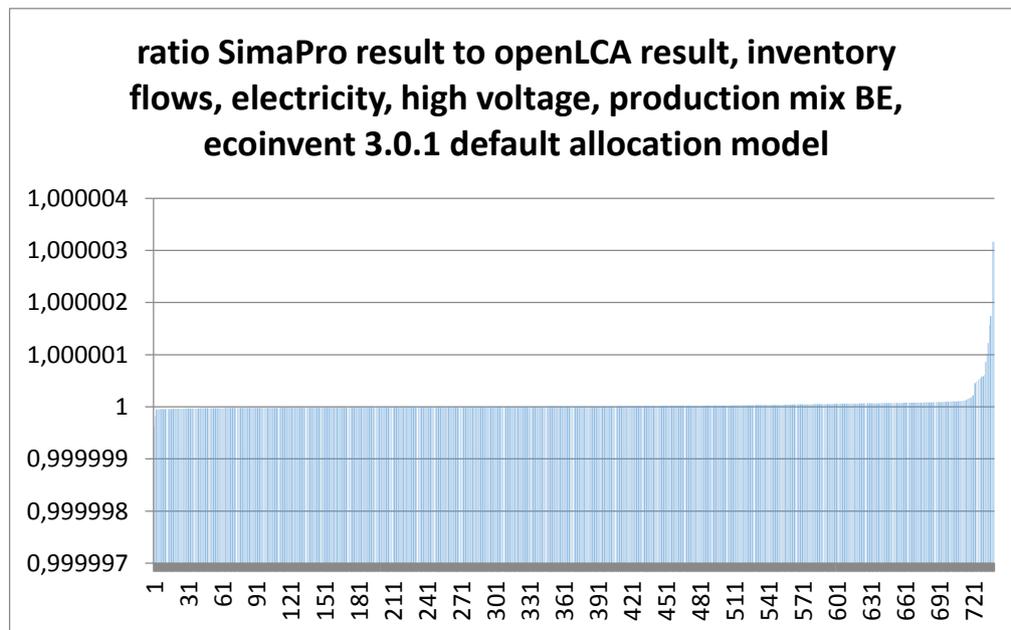
Figure 24: Ratio of calculation results, in ascending order; the x-axis shows the flow number

This is result of a life cycle calculation with about 7,500 unit processes included.

5.2   Performance

Improving the performance also for large life cycle systems was one of the core tasks in the development of openLCA 1.4. Table 3 presents some results (Windows 64 bit version, Windows 8.1, identical, modern notebook computer, calculation of the inventory only), also in comparison to SimaPro 8.

Table 3: openLCA and SimaPro performance comparison in network / analysis calculation

	Time required [seconds]		Ratio: required time
	openLCA 1.4	SimaPro 8.0.3	SimaPro / openLCA
Ecoinvent 3.0.1 default allocation horn meal production RoW			
Creating a product system*	10.17		*
Analysing / calculating a product system*	34.26		*
Total**	44.43	95.35	2.17
Ecoinvent 3.0.1 default allocation electricity high voltage production mix BE			
Creating a product system*	10.17 (2nd time: 4.18)		*
Analysing / calculating a product system*	33.03		*
Total**	43.20	86.52 (2nd time: 21.73)	2.00

* not available in SimaPro as separate action, always performed when calculating a network in SimaPro
** for openLCA, addition of time for creating and calculating the product system; opening an already created product system in openLCA takes about one second.

SimaPro is used as a benchmark here since it is the only other broadly used LCA software system (at least to our knowledge) that is able to calculate large unit-process based product systems from ecoinvent 3 so far. For the performance tests, the identical computer was used, no other user was interfering with the SimaPro multi-user Developer version; in openLCA, the 'analysis' calculation option was selected which produces results similar to the network calculation in SimaPro which in turn was used for SimaPro.

The table shows that openLCA is at least twice as fast as SimaPro when calculating a large ecoinvent unit process life cycle. This is also shown in the figure below. Both software systems become faster when repeating identical tasks, e.g. when the same product system is deleted and created again, due to caching procedures; in SimaPro, especially a repeated calculation is finished much quicker. In openLCA, a once created product system can be stored; reopening it takes only about one second and saves the time for recreating it. openLCA offers further a 'quick results'

openLCA

calculation were only main contributors and inventory and impact assessment tables are calculated; this quick calculation is about twice as fast as the analysis calculation (e.g., 17.59 seconds for the electricity product system above).
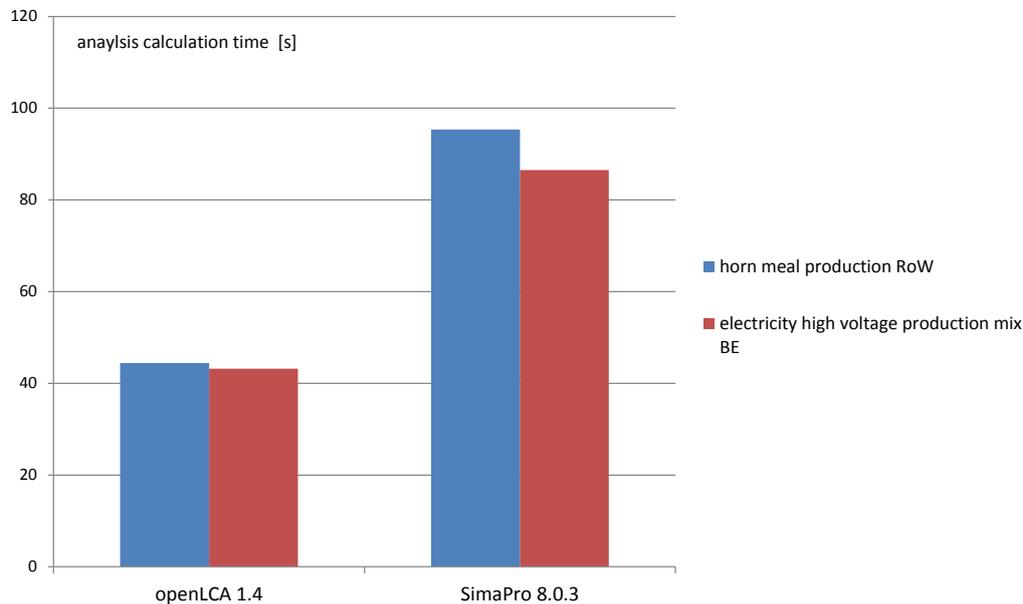

Figure 25: Calculation time comparison, SimaPro (network calculation) and openLCA (product system creation and analysis calculation), on the identical computer, further explanation see text

6   Using openLCA as format converter

6.1   Principles

openLCA 1.4 has many import and export interfaces

Import interfaces are:

- EcoSpold01
- EcoSpold02
- ILCD
- SimaPro csv
- (and also ILCD datahubs and openLCA 1.3 databases)

Export interfaces are:

- EcoSpold01 processes
- EcoSpold01 LCIA methods
- EcoSpold02 data sets
- ILCD data sets
- Excel templates for processes

- ICLD data hubs
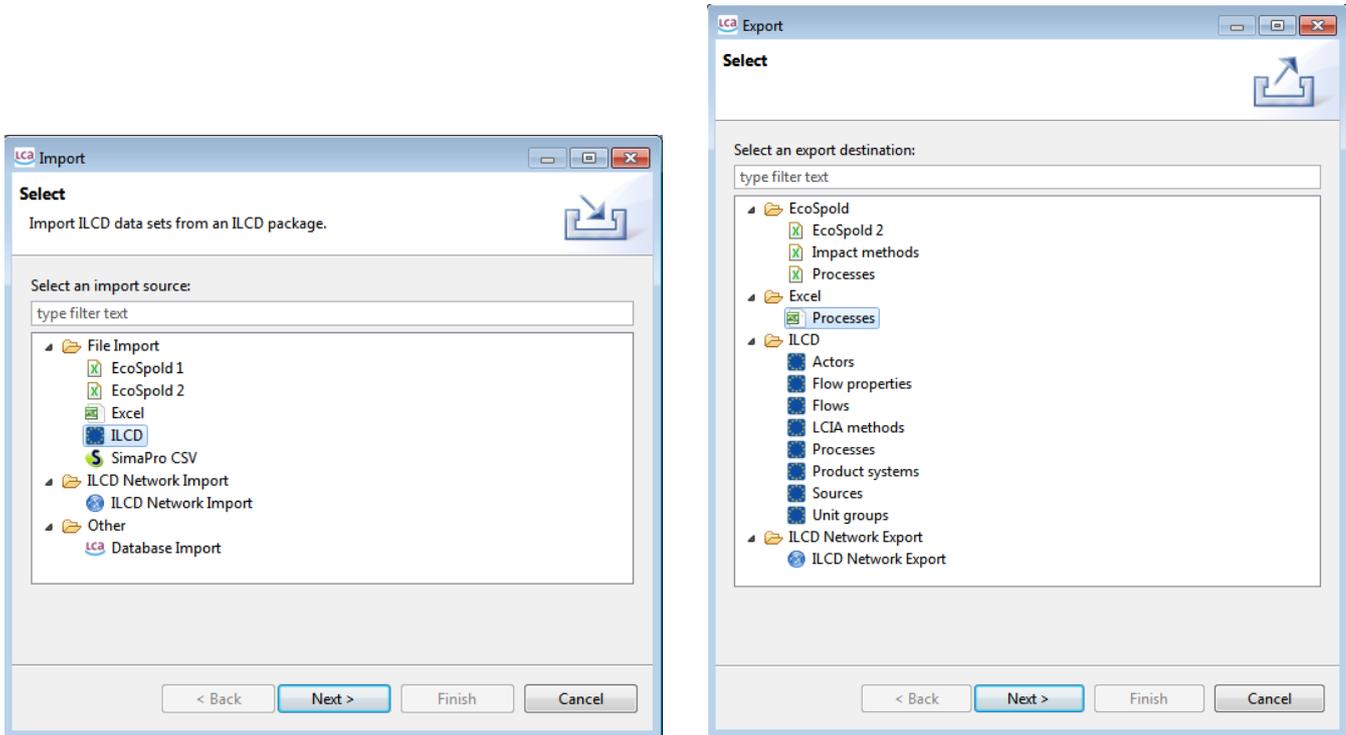
Figure 26: openLCA export and import options

Via import and export, openLCA can be used as a format converter. In fact for openLCA, we merged the conversion capabilities of the openLCA format converter in its most recent version 3 with the import and export features of openLCA. Since the introduction of the nexus reference information, the mapping in openLCA (LCA application) was more complete than the mapping available in the format converter.

For many of the import and export options, the conversion is straightforward. As a more complicated example, we will explain how to use openLCA to convert csv files created from SimaPro intoEcoSpold02 files that can be read and further processed in the EcoEditor developed for the ecoinvent centre[2].

6.2   Converting process data sets form SimaPro to EcoSpold02 using openLCA

SimaPro CSV export

First step is to select the processes you want to export, in SimaPro:

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[2] This feature was commissioned by the ecoinvent centre, for EcoEditor version 3.3.65.10874 from December 2 2013.
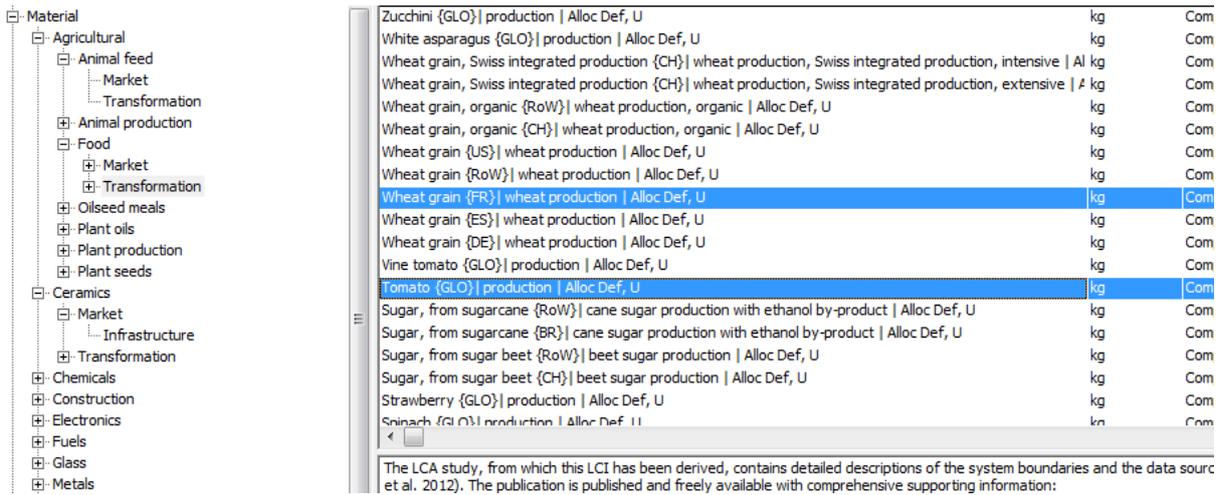
Figure 27: Process selection in SimaPro as first step

Open the export wizard under 'File/Export'. Select 'CSV file' as output type, semicolon as format option, and the processes you want to export under 'Selection'. Save the file.
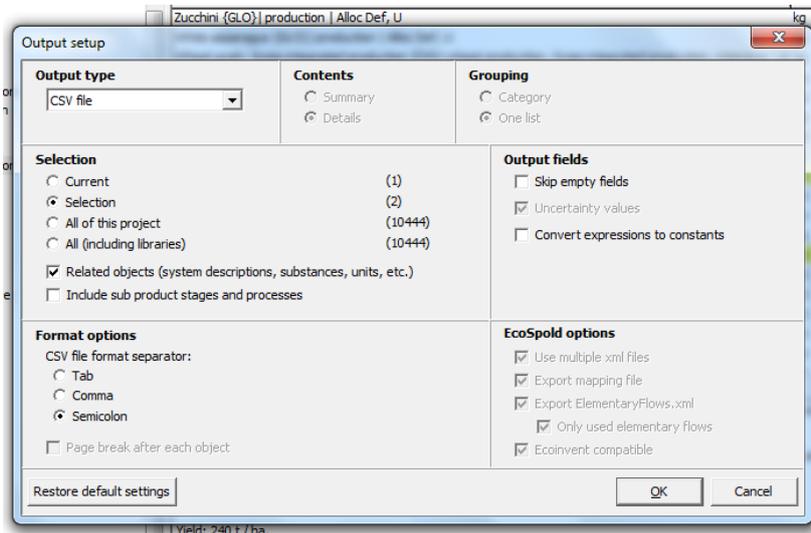

Figure 28: SimaPro csv export options selection for creating the csv files

Import the SimaPro CSV file into openLCA

As a next step, create a new database in openLCA via the context menu in the openLCA navigation view (alternatively, you can use an existing database and open it with a double click):

openLCA 1.4 overview and first steps, version 1, June 2014
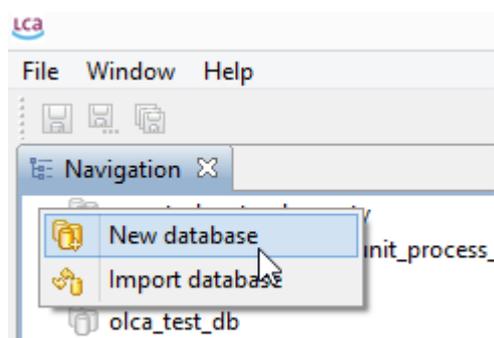
Create a local database with the option 'Complete reference data' (we need the reference data for mapping flows, units etc.):
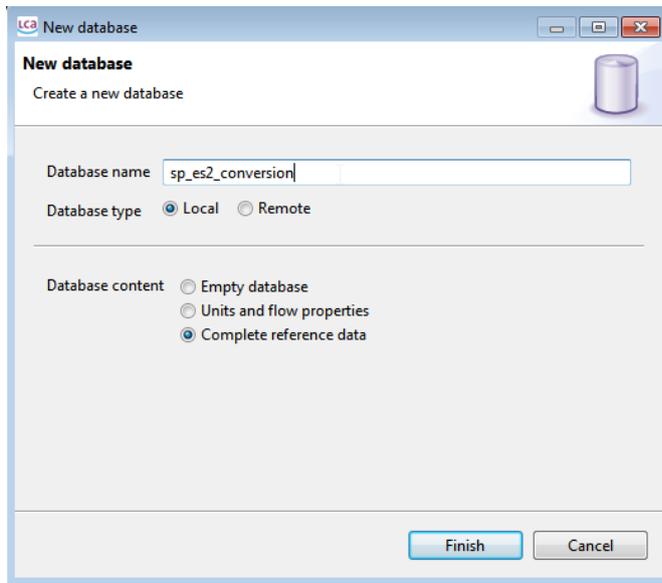

Right click on the database and select 'Import':
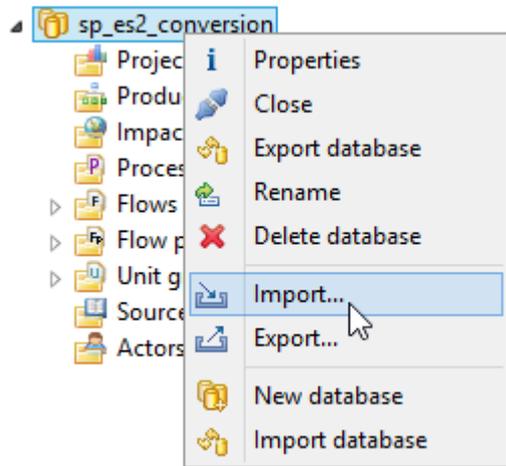
Figure 29: Importing into the database

In the import select 'SimaPro CSV' as import option and select the CSV file you want to import:
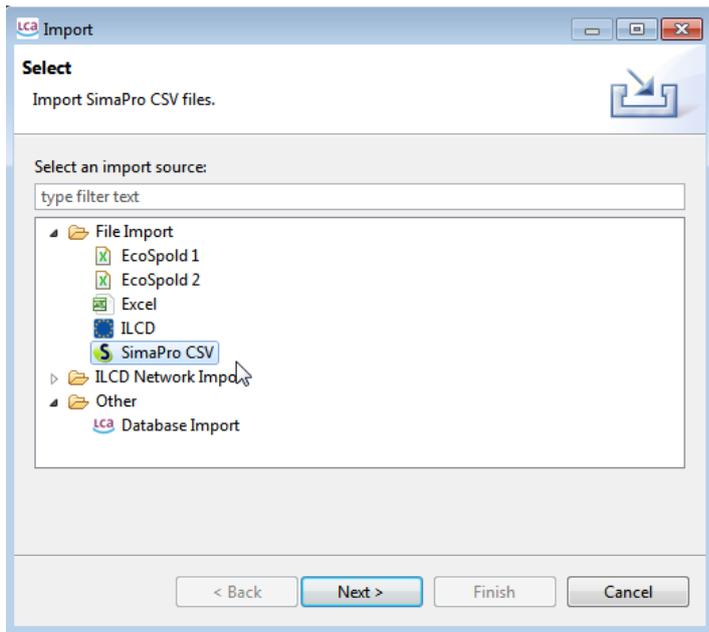
After the import you will see imported data sets under the same process categories as in SimaPro:
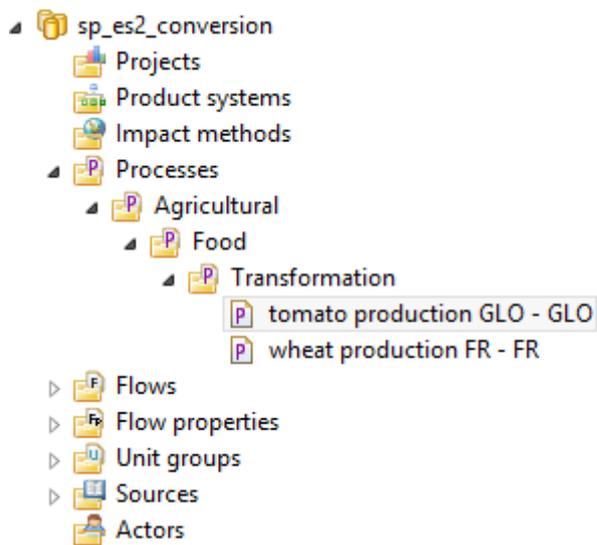

Figure 30: Processes imported in openLCA, as second step in the conversion

Export the processes from openLCA to EcoSpold02

Next step is to export the processes to EcoSpold02 format. To start this, right click on the database and select 'Export' (figure 31).
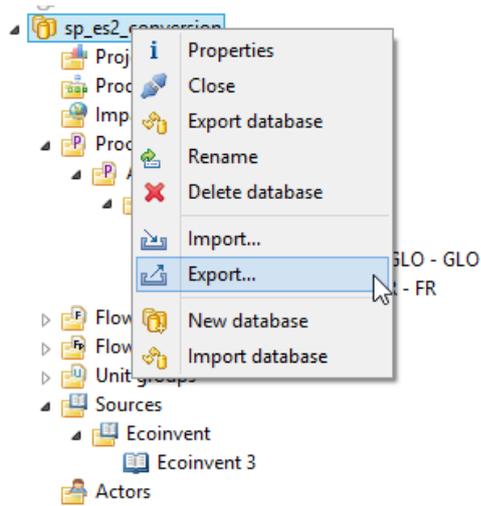
Figure 31: Exporting the processes

In the export wizard, select EcoSpold 2 as export option:
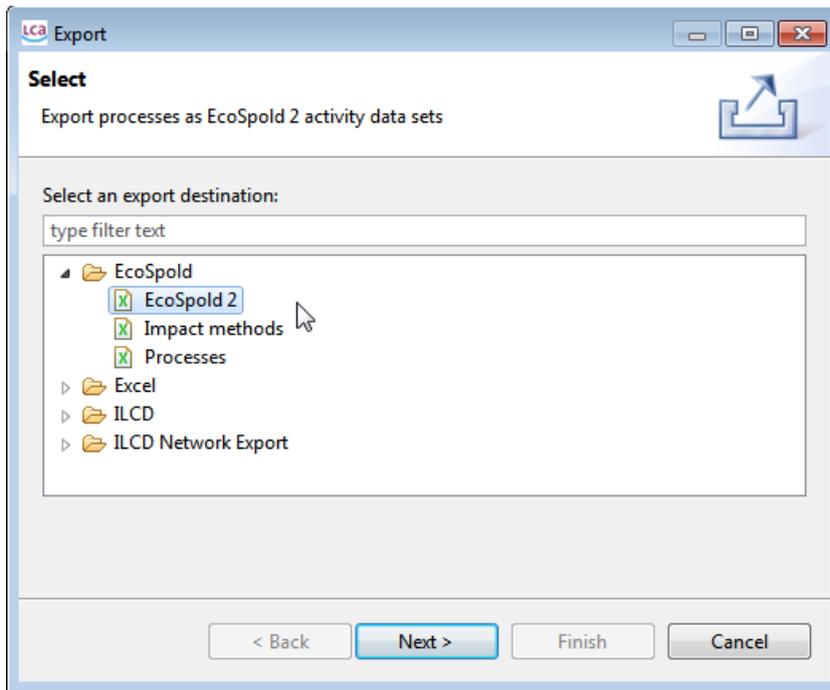
Select the processes you want to export and an export directory where the files should be written:
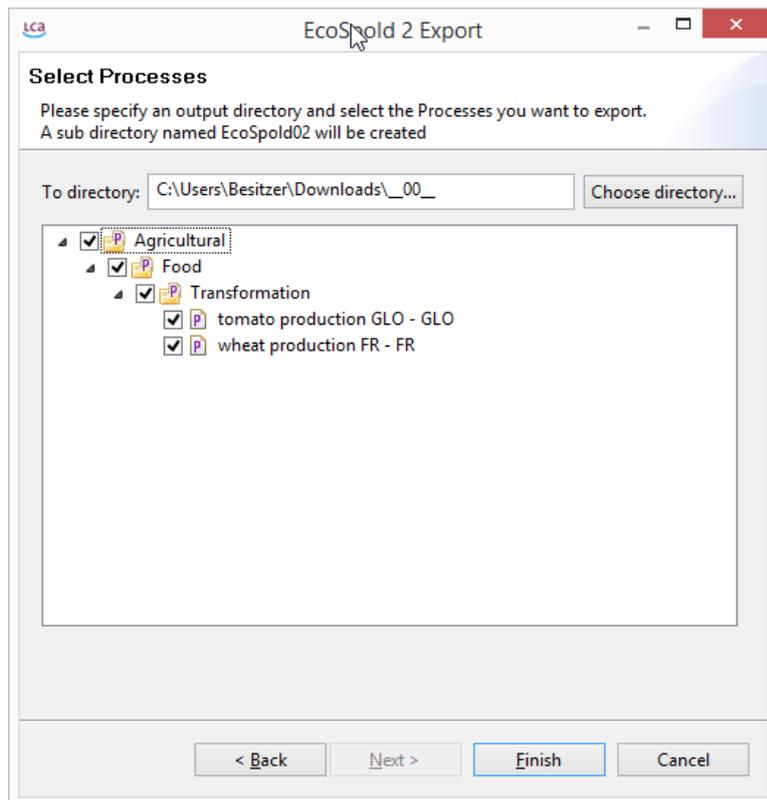
Figure 32: Selecting the processes for export in openLCA

<u>Open the data sets in the EcoEditor</u>

Third step of the conversion is to open the created files in the EcoEditor which reads (a specific version of) the EcoSpold02 format. This needs some preparation. The EcoEditor cannot open EcoSpold02 files with unknown "master data". Master data are for example flows, sources, units, compartments, locations etc. Thus, you first need to import the master data in the Eco-Editor before you can open the converted files. Select 'Import User Master Data From File' form the menu and select the EcoSpold02 file which you want to open:
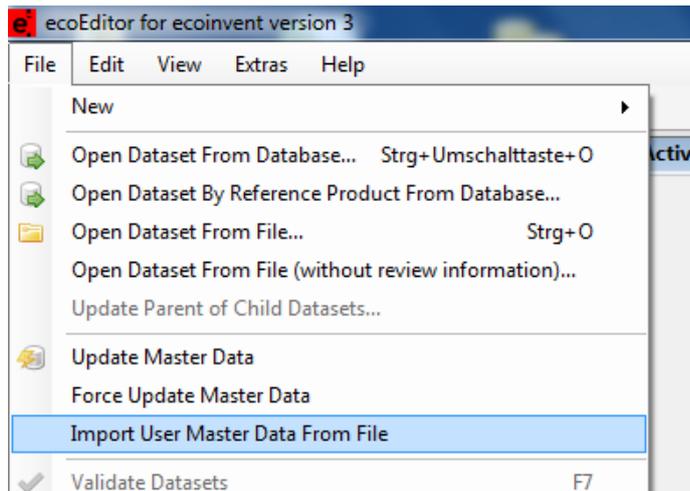
Figure 33: EcoEditor: Importing master data

After this, you should be able to open the data set from an EcoSpold02 file:
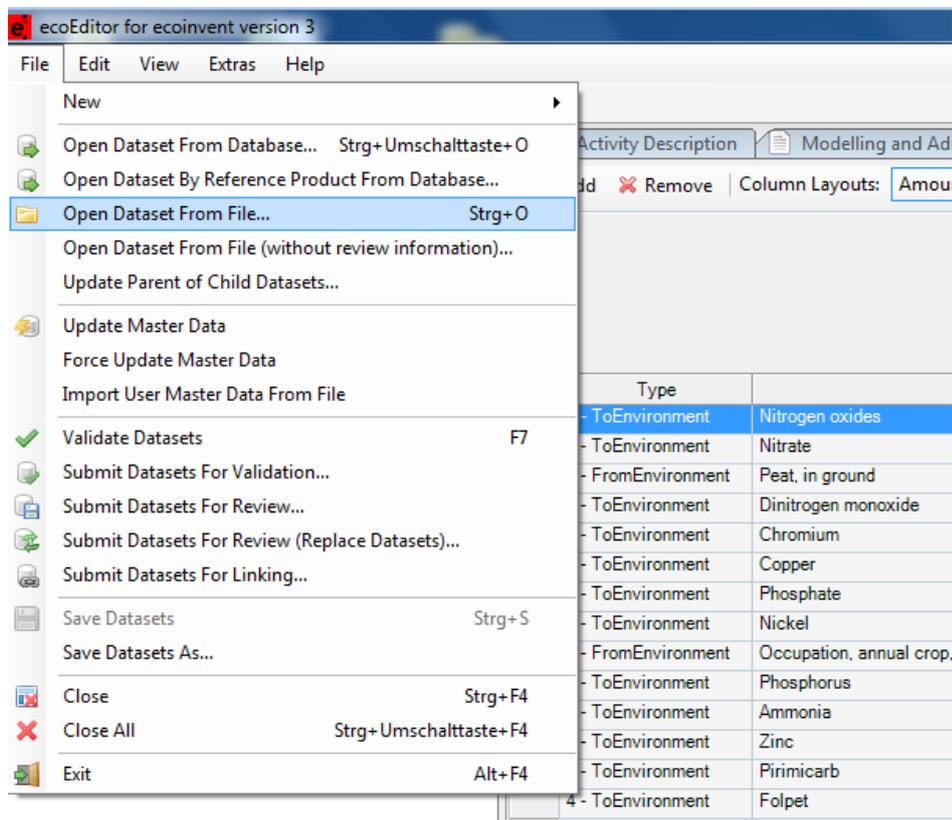
Figure 34: Opening the datasets in the EcoEditor

Remove/Reset the imported master data

If you want to remove the imported master data in the EcoEditor, go to the installation folder of the EcoEditor under …/Documents/ecoinvent/EcoEditor and remove the XML files under xml/MasterData/Production/user. You may backup this folder before you delete these files.

Conversion issues

Field length

In SimaPro 8 product names can be something like: *Heat, central or small-scale, other than natural gas {Europe without Switzerland}| market for heat, central or small-scale, other than natural gas | Alloc Def, U*

This string has 161 characters but only 120 characters are allowed in the EcoSpold02 format and accepted by the EcoEditor:
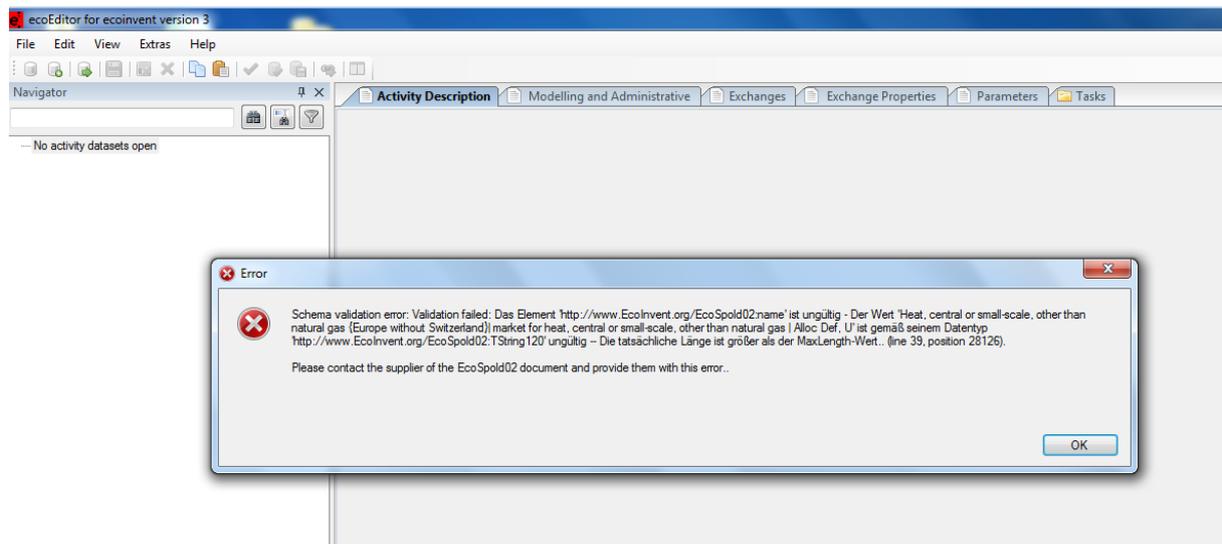
Figure 35: Validation error message in the EcoEditor due to a too-long field name that is not allowed in EcoSpold02 (now avoided since product names longer than 120 characters are truncated)

Thus, we have to cut names that are longer than 120 characters.

Meta-data mapping

Most of the meta-data are in a different format in SimaPro and EcoSpold02 / EcoEditor, e.g.

- Categories: tree in SimaPro <-> flat list that cannot be extended in the EcoEditor
- Time: fixed enumeration in SimaPro <-> start and end date in EcoSpold02
- Geography: only five locations in SimaPro
- Contact information: free text in SimaPro <-> structured person tags in EcoSpold02
- …

Some of these issues can be fixed when editing the data set after the export in openLCA or the EcoEditor.

6.3   Conclusions

The conversion example presented above is more complicated than others but it shows some of the issues in any conversion. The current LCA systems do not recognize "each other's" requirements too much, and in this situation the conversion cannot work completely by using "just" a software tool. It will never be possible to convert a free text contact information into structured person tags asking for first name, last name, asf. Therefore, typically, some additional work with the data sets is needed to fully meet strict definitions of target formats or target software systems. Aim of the converter functionality is to cover as much as possible, minimising the need for additional work. Switching from the openLCA format converter to openLCA has improved the conversion due a better meta data conversion and a better mapping database and thereby further reduced the need for additional work.

We are pleased to be part of an ongoing project commissioned by JRC to further improve the mapping and conversion of data sets, specifically to and from EcoSpold02 and ILCD.

7   Further reading

This short text cannot cover all aspects of the new openLCA 1.4 version.

More information is available here:

- A more extended description of openLCA and of how to use it for Life Cycle Assessment and sustainability assessment: www.openlca.org/manuals
- An overview of features and new features: www.openlca.org/features
- Examples for usability improvements and changes in openLCA: www.openlca.org/features#usability.
- A more detailed, yet a bit older performance test comparing SimaPro 7.3.3, SimaPro 8.0.0, openLCA 1.3.4 and openLCA 1.4 beta III: www.openlca.org/performance.
- We provide a definition and discussion of open source licenses on the openLCA website, here: www.openlca.org/open-source.

... enjoy! And if you have any feedback, please contact us.

8 Contact

openLCA is developed and managed by GreenDelta in Berlin. If you have any feedback, comments, questions, please let us know.

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Open Source Software for Life Cycle Assessments and for Sustainability Assessment

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9 Final remark: Big thanks

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(if you are also interested in specific features or modifications of openLCA – please let us know. We develop software).