

openLCA Tutorial

February 18, 2016

1 About the tool

openLCA is an open source tool developed by GreenDelta in 2007 for Life Cycle Assessment (LCAs) and sustainability assessment studies. LCA is a popular tool used by businesses to identify opportunities to reduce resource use and emissions, optimize their business approach and make informed decisions based on economic and environmental criteria. openLCA is one of the most comprehensive tools available today, to perform this task and is widely used by many industries and NGOs. [The link to download the tool is available here](#). This tool is also available in the computer labs (Room 110-120 CBEC).

2 Download & Installation

openLCA is available for Mac, Linux and for both 32 bit and 64 bit Windows version. Installation procedure varies for different operating systems but is quite straight forward. More information on the installation procedure is available in the following [link](#).

Once you download and install the software, the navigation screen will be empty that looks like this (Figure 1). The navigation pane is where information on the different projects you create will be stored. The first step is to create a new database. Right click on the navigation pane and click on "New database". Give a name to your database and ensure that the "Local" radio button is checked. Creating local projects will make data sharing and transfer easier. Next, click on the "Complete reference data" in the database content option and click on "Finish". Your new database will be visible in the navigation pane. You will notice that the new database is almost empty, except for some inbuilt flows, flow properties and unit groups.

3 Life cycle inventories and impact assessment methods

Once you create a new database, the next step is to download and import the *Life Cycle Inventory Database* and the *Impact Assessment Methods*. These two datasets are required to build your model in openLCA.

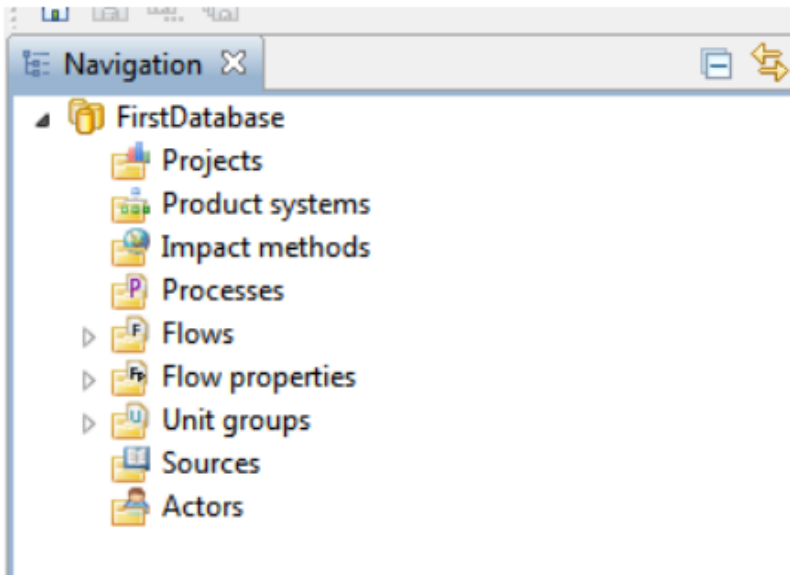


Figure 1: Your first database in openLCA

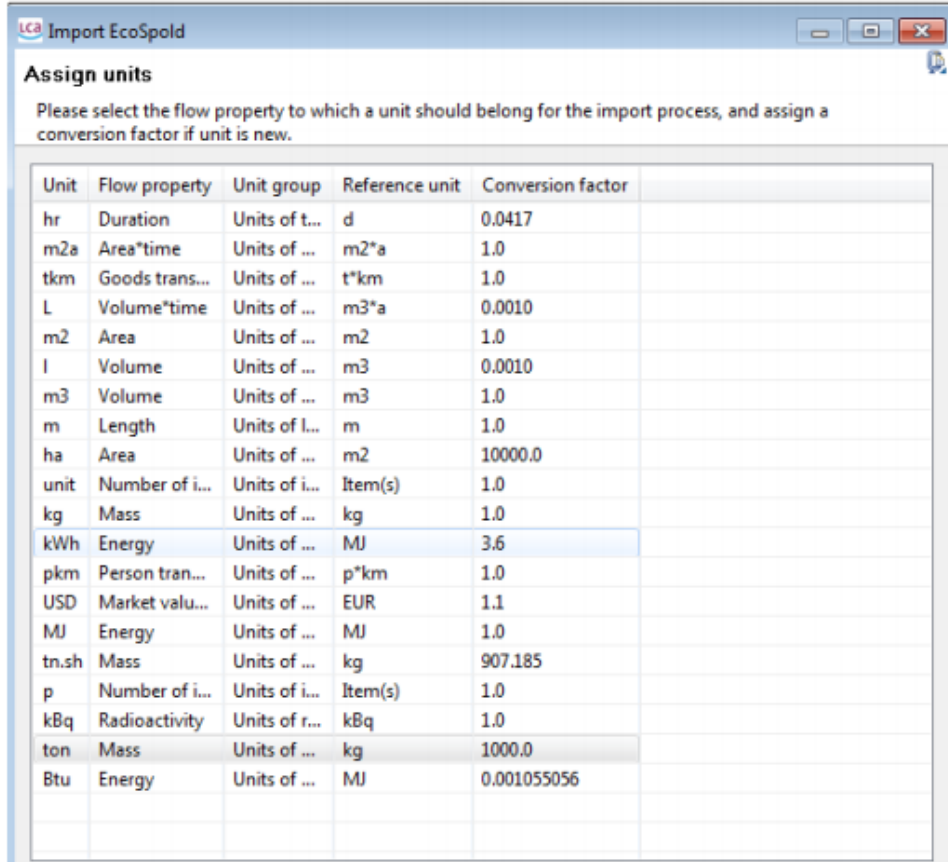
3.1 Life cycle inventory database

The life cycle inventory database contains a set of input and output flows from different product systems including material, energy and emissions flows. There are many free databases from where you can download these life cycle inventories including the NREL (National Renewable Energy Laboratory), NEEDS (New Energy Externality Development for Sustainability, European), ProBas(European) database. You can find a whole list of data sources provided by openLCA [in the link provided here](#). The most common one used in the U.S. is the NREL database and they have a set of about 2000 elementary flows and 900 product flows defined. The database can be downloaded from the [NREL website](#). The dataset is also available as a .zip file on Carmen, in case you have any issues downloading the dataset from this link.

To import the life cycle inventory dataset into your database, right click on Process → Import. In the dialog box that appears, choose Eco Spold 1 under the “File import” menu and click next. To import the database, navigate to the folder location where the database was downloaded, and click on the “NREL USLCI Database.zip” file and click next. Some of the units in the NREL database is not compatible with the openLCA tool and these have to be defined manually. Use the values given in Figure 2 to assign the missing units.

Alternatively, you can also import the Eco-invent database into openLCA. openLCA versions 1.4.x does not support the xml file available in the ecoinvent website (v2.2 or lower) directly. However, the openLCA nexus website has a version of the ecoinvent database that is compatible with openLCA version 1.4. The commercial database can be downloaded from the [link available here](#).

Process data from SimaPro can also be converted to a csv format and imported into openLCA. To import processes from SimaPro, the first step is to download the process that you want to import into a “.csv” format. The next step is to import the csv file into an



Unit	Flow property	Unit group	Reference unit	Conversion factor
hr	Duration	Units of t...	d	0.0417
m2a	Area*time	Units of ...	m2*a	1.0
tkm	Goods trans...	Units of ...	t*km	1.0
L	Volume*time	Units of ...	m3*a	0.0010
m2	Area	Units of ...	m2	1.0
l	Volume	Units of ...	m3	0.0010
m3	Volume	Units of ...	m3	1.0
m	Length	Units of l...	m	1.0
ha	Area	Units of ...	m2	10000.0
unit	Number of i...	Units of i...	Item(s)	1.0
kg	Mass	Units of ...	kg	1.0
kWh	Energy	Units of ...	MJ	3.6
pkm	Person tran...	Units of ...	p*km	1.0
USD	Market valu...	Units of ...	EUR	1.1
MJ	Energy	Units of ...	MJ	1.0
tn.sh	Mass	Units of ...	kg	907.185
p	Number of i...	Units of i...	Item(s)	1.0
kBq	Radioactivity	Units of r...	kBq	1.0
ton	Mass	Units of ...	kg	1000.0
Btu	Energy	Units of ...	MJ	0.001055056

Figure 2: NREL - openLCA flow units

openLCA database. Right click on the database that you have created and click on import. Choose the “SimaProCSV” option under the “file import” folder and choose the “.csv” file that you just exported from SimaPro. After the import, you will see the process under the same category as in the SimaPro database.

Note: If you are using this tool for class projects, you should use the LCI database provided by the NREL.

3.2 Impact Assessment Methods

Life Cycle Impact Assessment (LCIA) methods are necessary to analyze the impact inventory obtained from an LCA model. Impact assessment methods establish a link between emissions from manufacturing multiple products or operation of processes and its potential environmental impacts. Each impact assessment method contains different impact categories which are location specific. For example, CO₂ emissions and N₂O contribute to global warming while emissions of H₂S or hydrogen sulfide gas can contribute to human toxicity. LCIA methods quantify the environmental consequences of these emissions based on different characterization factors. Going through the different impact categories in each method prior to building the LCA model is advisable. More information on the different assessment methods can be found [here](#).

The LCIA method pack available in the openLCA nexus is a comprehensive package of different impact assessment methods including GaBi, ecoinvent 3, and the ELCD. Triangle Life Cycle Assessment LLC in collaboration with GreenDelta have also developed a comprehensive package with different impact assessment methods that is applicable for a U.S LCI database.

To download these impact assessment methods in openLCA, click on the LCIA methods in the [download page](#). Once you have it downloaded, you can import the database saved as a .zolca file. “.zolca” files are unique extensions given to openLCA files and every time you save or import your database, your files have to be in this format.

Right click on the Impact Assessment tab in the new database that you created and click on import. Choose the “Database Import” option under the other subfolder. Now navigate to the directory where the .zolca file was downloaded and click on finish.

4 Building the openLCA model

4.1 Distinguishing flows and processes in openLCA

Before you begin to build your model, here is a small clarification on the difference between flows and processes in openLCA. Flows and flow properties form the basis for building openLCA models and performing the calculations. Industrial systems (in this case “Processes”) in openLCA are an entity by itself with environmental and material inputs defined by flows, and environmental and resource outputs quantified by different flows again. This makes it easy to analyze the production of multiple products from a single process.

4.2 Building your model

Any LCA analysis begins with modelling the product system under study. Product systems can be created in three different methods depending on the amount of data available and user preferences.

4.2.1 Creating a product system from process data

Users can create a new product system from existing processes in openLCA. To create a product system from process based data, choose the process system pertaining to your problem. In the *General Information* tab, click on “Create product system” and click on finish. Specify the functional unit for your study along with flow units in the reference tab.

You can keep track of your assumptions by making note of it in the description tab. Once you have a product system defined, the model graph tab will display only the reference process system.

To build the entire life cycle model including the upstream contributions, right click on the *Product system* → *Build Supply chain* → *Complete*. Once this is done, click on the “Expand all” in the product system to view the entire supply chain.

These connections can be tweaked according to user’s preference and based on the system under study. This window is where most of the process modifications, editing and deletion can be done according to the nature of the problem.

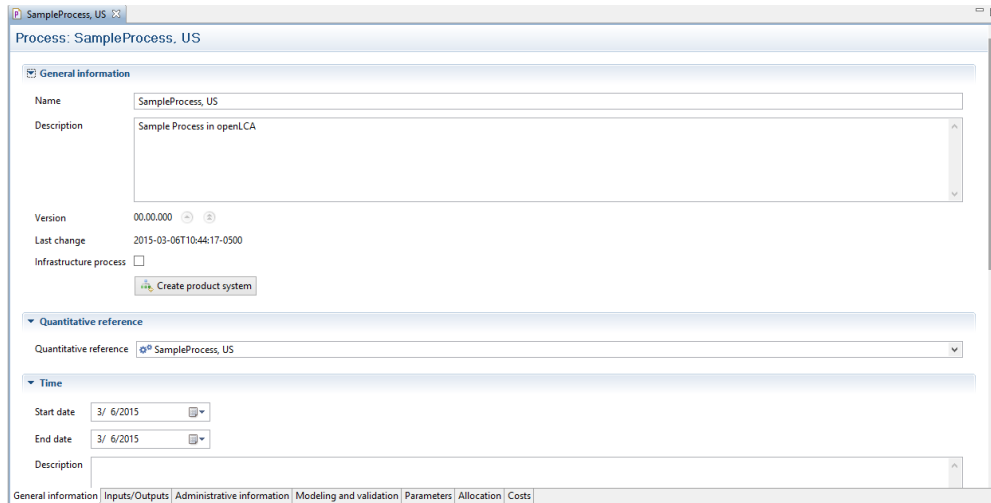


Figure 3: Sample Process

To determine the life cycle impact, click on the “Calculate” button in the *General Information* tab, and choose the method of allocation, the impact assessment method and the normalization or weighting set and hit “Calculate”. openLCA calculates impact contributions from each step in the life cycle of a product system. The number and type of impact category will depend on the type of impact assessment method selected by the user.

4.2.2 Manually adding processes

Another alternative to adding processes besides auto-connecting them will be to manually connect flows in the model graph. This option is useful if you like to modify some flows in the an existing product system to match your process description. This will be useful typically when you will have to swap the type of resource and energy input to a process. Once you build the supply chain for your process, you can manually add or remove connections in the process network. Right click on the process that has to be tweaked and choose either “remove connections” to remove a particular connection, “Search providers for” to search for flows upstream to the given process or “Search recipients for” option to choose flows downstream to the given system. To add a new process if a connection doesn’t exist, drag and drop the reference process system from the *Process* tab in the navigation tool bar and then build the connections by adding recipients and providers.

5 Sample Problem in openLCA

Here is simple example to compare the generation of 10 kwh of electricity from natural gas and biomass.

Assume we have a process that requires 10 kWh of electricity from two sources - Biomass and Natural gas. You want to compare the life cycle emissions for the production of electricity from the two different resources.

Building the model:

You will have to create two different models to do this comparison. For defining a product system for electricity from natural gas, click on the *Process* → *Utilities* → *Fossil Fuel Electric Power Generation*. If you look into the *Input/Output* tab the first output flow is the “Electricity, natural gas, at plant” process, which has a reference amount of 1 kwh here. Remember, this is **not** where you define your functional unit.

If you wish to make some modifications to the input process, simply add a new process to the inputs tab by clicking on the green plus menu to add a new input flow. Select the input flow from the table and delete the existing process. For example, in the natural gas electricity process, if the mode of transport for your process was truck instead of diesel powered train, simply choose the required flow, and define the appropriate amount. The t*km(Tons*km) will vary depending on the type of vehicle used for transportation and the tkm values have to be calculated for the vehicle being used. You can explore more about the entire supply chain network by expanding each process, and analyze all the flows back to the first step in the entire supply chain.

Similarly, to create a product system for electricity from biomass, click on Flows and search for “Electricity, Biomass, at plant” under the utilities tab. You will notice that, flows for electricity from Biomass already exist for the North American region. To create a product

The screenshot shows a software interface with two main sections: 'General information' and 'Reference'.

General information:

- Name:** Electricity, natural gas, at power plant - Sample
- Description:** A large empty text area with a vertical scrollbar.
- Version:** 00.00.000 with increment and decrement buttons.
- Last change:** A button with a green plus icon and the text 'Calculate'.

Reference:

- Process:** Electricity, natural gas, at power plant
- Product:** Electricity, natural gas, at power plant (RNA)
- Flow property:** Energy
- Unit:** kWh
- Target amount:** 10.0

Figure 4: Product system for electricity from natural gas

system for both the models, click on the “Create product system” option in the *General Information* tab. Give a name for your product system and click on finish. You will get a window that appears like this Figure 4. To do an impact analysis calculation, click on Calculate. Choose the type of allocation if any, the impact assessment method and click on Calculate.

You can then import the data into an excel file for further calculations. Do the same for the electricity from biomass process and compare the results of both processes in terms of GHG emissions, criteria air pollutants, water requirements, etc. For some processes, there is a possibility that flows do not exist. In this case, you will have to create flows to and from processes depending on the amount of information you have. To do this, right click on *Flow* → *Create new flow*. Give a name for your flow, define the type of flow (Elementary flow, product or waste) and a flow property as defined below in Figure 5.

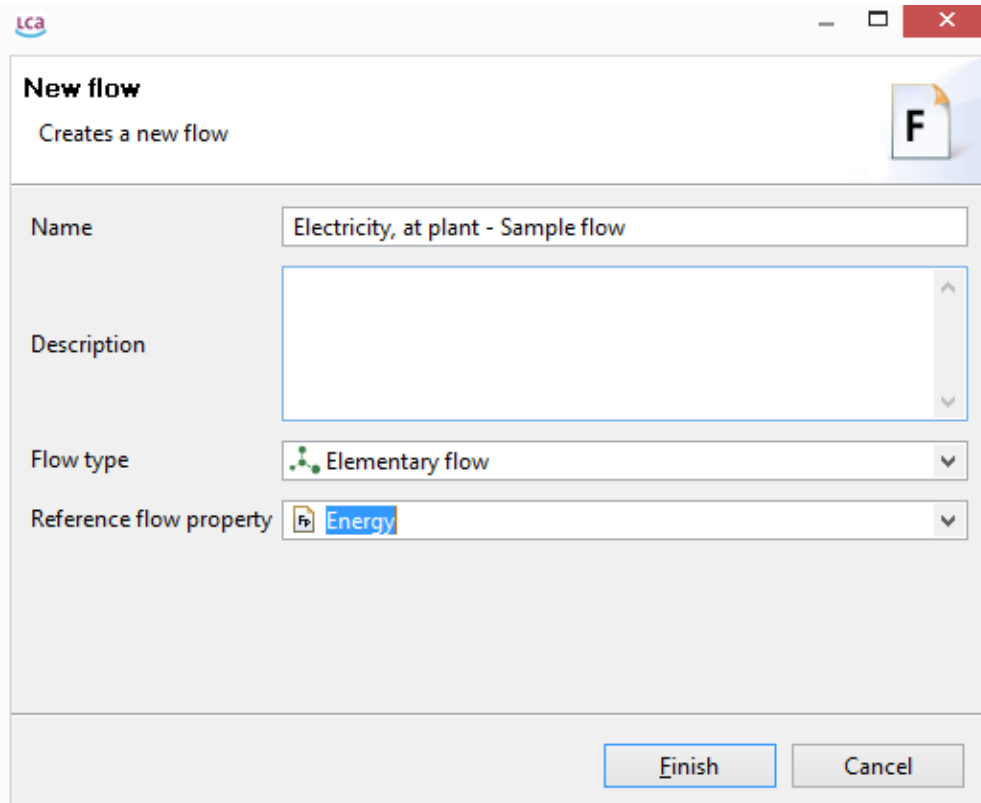


Figure 5: Defining a new process

6 Useful References

This is just a brief introduction to the tool. openLCA can be used to build complex systems and analyze the life cycle impacts. A lot of case studies are available online for your reference. Here are some useful manuals you can refer, to learn this tool.

1. [Over view and first steps](#)
2. [OpenLCA user guide](#)
3. [A simple example for manufacturing and installing rooftop photovoltaic systems](#)
4. [Case study of a Beer Bottle](#)
5. [Comparison of Conventional vs. Organic Viticulture](#)
6. [A comparison of different LCA models - SimaPro, Eco-LCA and openLCA](#)