openLCA 1.5

Case study viticulture - organic vs conventional production

Software Version: 1.5
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Content

1   Introduction

This tutorial aims at explaining a typical Life Cycle Assessment example, while using and discovering the openLCA software. Please consider that this is not a full LCA case study with realistic data. LCA data are given as example and are not meant to be accurate.

This text focuses on basics of environmental impact assessment in openLCA using the 1.5 version of openLCA. This includes step-by-step instructions for a contribution analysis of a product system under study and a comparison of environmental impacts of projects. If you feel that some steps are missing (instructions are not clear enough), please first refer to the basic modelling documentation.

The example given is based on the "ecoinvent 2.2" database, which can be downloaded from openLCA Nexus (https://nexus.openlca.org/databases). Please not that the version 2 and 3 of the ecoinvent databases differ significantly so that the flows and processes of the example will not be the same using the "ecoinvent 3" database. More information about changes of the ecoinvent database versions can be obtained in the ecoinvent documentation[2] .

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[2] http://www.ecoinvent.org/support/faqs/differences-between-ecoinvent-2-and-3/differences-between-ecoinvent-2-and-3.html

2   Goal and scope

Imagine that you work in a local agricultural union and have accepted the mission to improve environmental impacts of the local winegrowers. One of the obvious options seems to develop organic viticulture. To do so, you need figures to convince them that they can substantially reduce their impact while producing a good wine (taste is too subjective to be considered in this case).

You surveyed conventional and organic wine growers to find out their inputs and outputs. The" ecoinvent 2.2" database provides a large list of "already built" processes that fit your needs. This will help you to model both options and provide reasonable comparison. To ensure the comparison is adapted to a wine grower level, you do not consider the wine productions processes, the bottles, or the transport to customers.

3   Create a product system

- Create the process "Organic Viticulture Production" with the quantitative reference "grapes, organic"
- Create the process "Conventional Viticulture Production" with the quantitative reference "grapes, conventional"

To create a new folder into "Flows" called "1.5 Viticulture", right click and select "Add a new child category". Do the same into the "Processes", the "Product systems" and "Projects". This way, you can keep everything you will create altogether.

To create a new flow as a quantitative reference for the process, right click on the new folder created for flows, select "Create a new flow", name it "grapes, organic", select "Product flow" as flow type and choose the reference property "Mass".

To create a new process, right click on the new folder created for processes, select "Create a new process", name it "Organic Viticulture Production" and select the quantitative reference "grapes, organic". Add the input and output flows according to table 1, adjust the respective amounts and define the providers for each input flow. Remember to save the changes made.

Table 1 Input and output flows for the process "Organic Viticulture Production"

Input flow	Category	Amount
compost, at plant	Agricultural means of production/organic fertilizer	2 kg
horn meal, at regional storehouse	Agricultural means of production/organic fertilizer	1 kg
diesel, at regional storage	Oils/fuels	0.005 kg
transport, lorry 7.5-16t, EURO5	Transport systems/road	0.000001*248 t*km
Occupation, arable	Ressource/land	0.00286*1 m^{2}a

Output flow	Category	Amount
Grapes, organic	Case Study Viticulture	1 kg

Phosphate	Water/ground water	0.000053 kg
Ammonium, ion	Water/ground water	0.000067 kg
Nitrate	Water/ground water	0.074

To create a product system, go to the "General information" tab of the process created and use the "Create product system" button, select the reference process "Organic Viticulture Production", select "Add connected processes" and "Connect with system processes if possible".

Then repeat each step described as above for creating the product system "Conventional Viticulture Production" with the input and ouput flows accoding to table 2.

Table 2 Input and output flows for the process "Conventional Viticulture Production"

Input flow	Category	Amount
diammonium phosphate, as P2O5, at regional storehouse	Agricultural means of production/mineral fertilizer	0.046 kg
horn meal, at regional storehouse	Agricultural means of production/organic fertilizer	0.01 kg
fungicides, at regional storehouse	Agricultural means of production/pesticides	0.56 kg
herbicides, at regional storehouse	Agricultural means of production/pesticides	0.0.53 kg
insecticides, at regional storehouse	Agricultural means of production/pesticides	0.0008 kg
boric oxide, at plant	Chemicals/inorganics	0.0002 kg
magnesium oxide, at plant	Chemicals/inorganics	0.076 kg
diesel, at regional storage	Oils/fuels	0.005 kg
transport, lorry 7.5-16t, EURO5	Transport systems/road	0.000001*248 t*km
Occupation, arable	Ressource/land	$0.00286*1\,m^2*a$

Output flow	Category	Amount
Grapes, conventional	Case Study Viticulture	1 kg
Phosphate	Water/ground water	0.00012 kg
Ammonium, ion	Water/ground water	0.00014 kg
Nitrate	Water/ground water	0.566 kg

The product system "Organic Viticulture Production" should look like Figure 1.
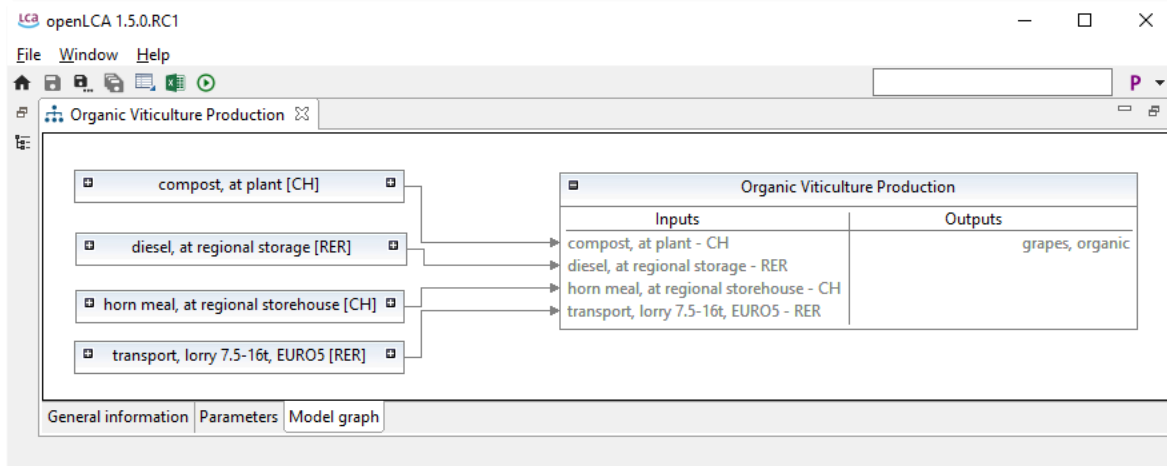
Figure 1 Model Graph of the product system "Organic Viticulture Production"

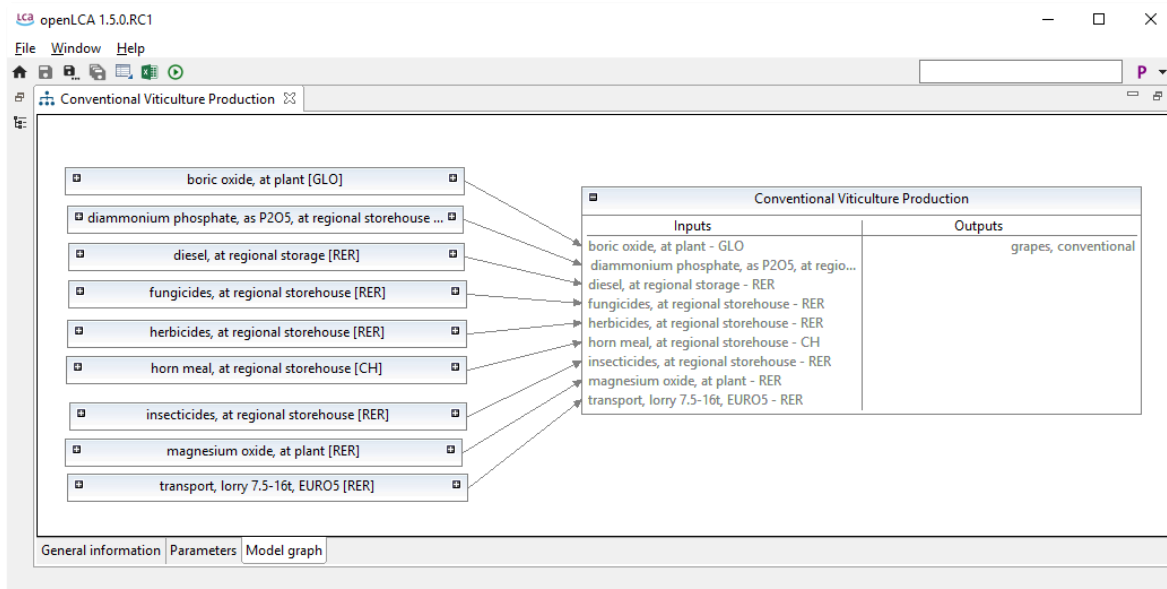The product system "Conventional Viticulture Production" should look like Figure 2.

Figure 2 Model Graph of the product system "Conventional Viticulture Production"

4 Impact Assessment of a project

- Create the project "Viticulture - Organic vs Conventional Production"
- Calculate the environmental impacts of the project using the "CML (baseline)" LCIA method

To create a project, right click on the folder created for projects, select "Create a project" and name it "Viticulture - Organic vs Conventional Production ".

Select the LCIA method "CML (baseline)" in the LCIA method section and select the following impact categories:

• Acidification potential – average European
• Climate change – GWP 100
• Eutrophication - generic

- Freshwater aquatic ecotoxicity – FAETP inf
- Human toxicity – HTP inf
- Terrestrial ecotoxicity – TAETP inf.

Add the product system "Organic Viticulture Production" in the compared product systems section and name it "Organic". Add the second product system "Conventional Viticulture Production" and name it "Conventional". When you have finished the project setup, click "Report".

The report view will open up as a new window in the editor and the relative results should look like Figure 3.

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.

Impact category	Conventional	Organic	Unit
Acidification potential - average Europe	3.88232e-2	7.13273e-3	kg SO2 eq.
Climate change - GWP100	6.66120e+0	2.05997e+0	kg CO2 eq.
Eutrophication - generic	8.14380e-2	9.02601e-3	kg PO4--- eq.
Freshwater aquatic ecotoxicity - FAETP inf	1.93357e+0	4.86366e-2	kg 1,4-dichlorobenzene eq.
Human toxicity - HTP inf	1.35685e+1	1.08941e-1	kg 1,4-dichlorobenzene eq.
Terrestrial ecotoxicity - TETP inf	6.61696e-2	1.71453e-3	kg 1,4-dichlorobenzene eq.

Relative Results

The following chart shows the relative indicator results of the respective project variants. For each indicator, the maximum result is set to 100% and the results of the other variants are displayed in relation to this result.
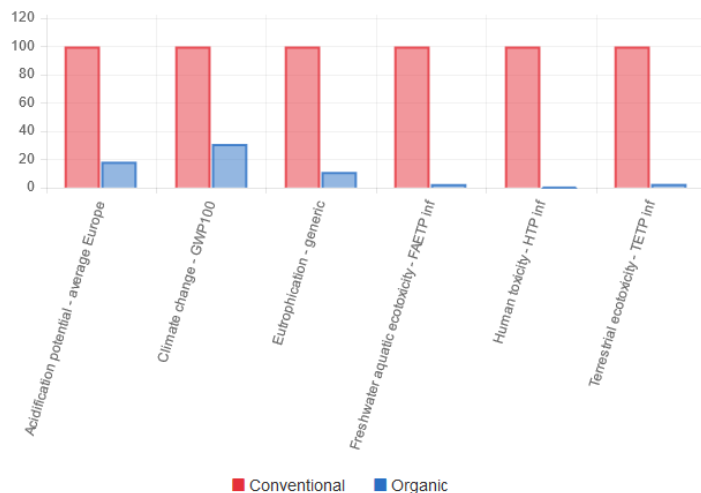

Figure 3 Environmental impacts of conventional and organic viticulture production using the "CML (baseline)" method (base case)

The environmental impacts of the conventional product system are higher for all selected impact categories as compared to the impacts of the organic product system.

5   Impact Assessment of a product system

- Calculate the environmental impacts of the process "Conventional Viticulture Production" using the "CML (baseline)" LCIA method

In order to find the main sources for higher impacts of the conventional product system go to the General information tab of the product system "Conventional Viticulture Production" and quantify the environmental impacts by clicking "Calculate". Select the same method as for the calculating the project "CML (baseline)" and the calculation type "Analysis".

5.1   Direct contributions of processes

In the direct contributions to impact category results - overview section you can see the five processes with the highest contribution for the impact category "Human toxicity - HTP inf". In this case, the process "o-dichlorobenzene, at pant - RER" has the highest direct contribution with 5,67 kg 1,4 dichlorobenzene equivalents (eq.) for the impact category human toxicity without its pre-chain required for the particular process.
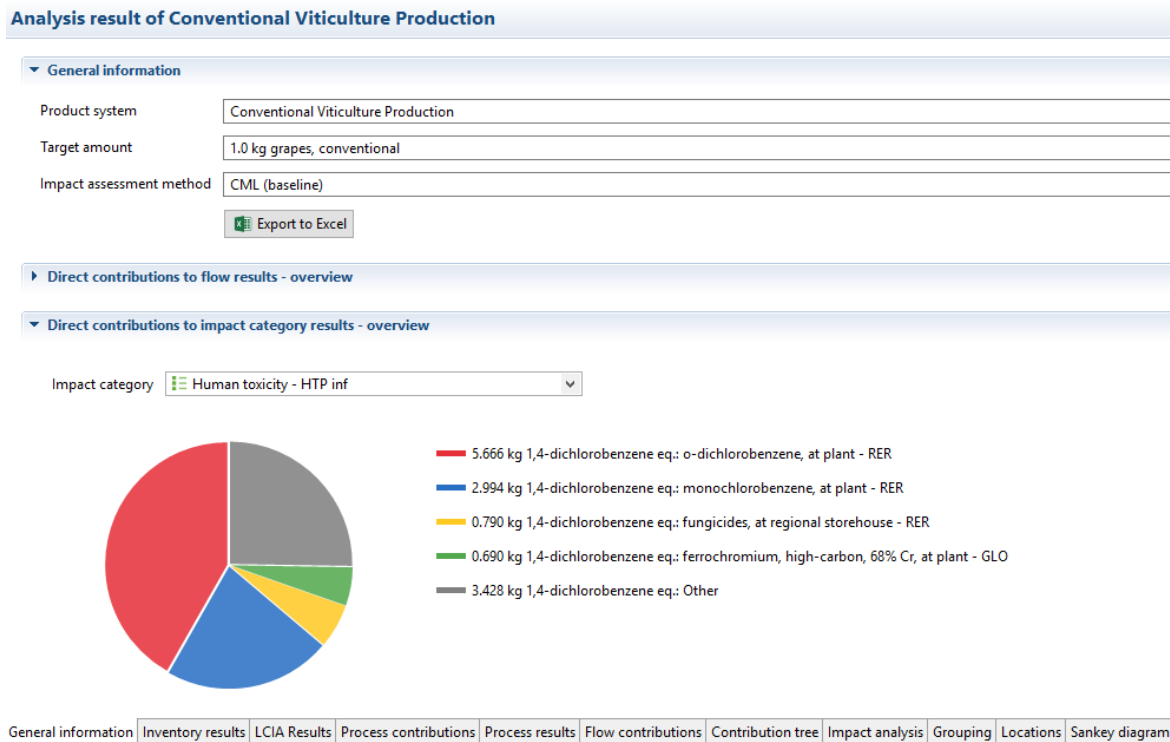

Figure 4 Direct contributions to impact category results - overview of the analysis results

The same information can be found in the process contribution tab in which the absolute amount of 5,67 kg 1,4 dichlorobenzene eq. and relative amount of 41,76 % of the process "o-dichlorobenzene, at pant - RER" are shown.
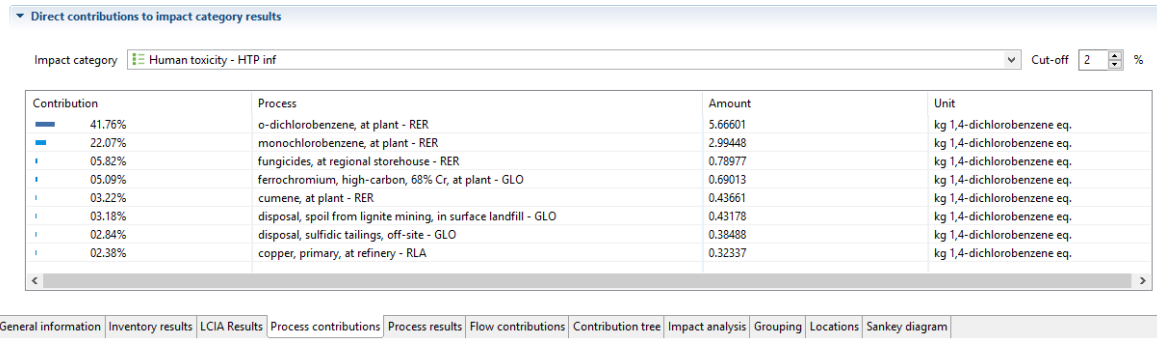
Figure 5 Process contributions tab of the analysis results

5.2 Direct Contributions of processes including the pre-chain

When you go to the contribution tree tab, you can see the direct contributions for each process including its respective pre-chain (as upstream total). The process "fungicide, at regional store house (RER)" including its pre-chain accounts for 12.34 kg 1,4-dichlorobenzene eq. which is 90.95% of the product system for the impact category human toxicity
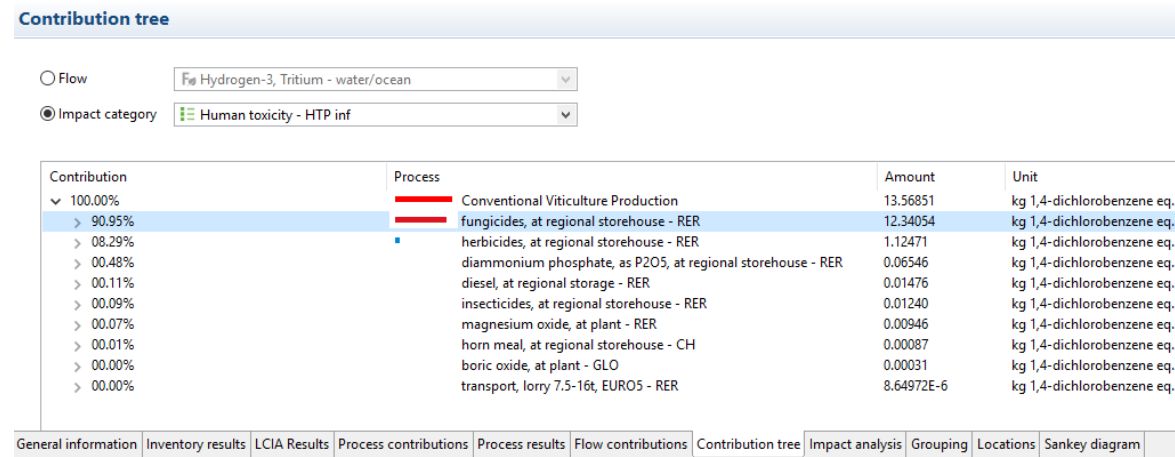

Figure 6 Contribution tree tab of the analysis results

When you go to the Sankey diagram tab of the analysis results, you can find the direct and upstream total contribution for each process. Set the Sankey diagram view with a right click and select "Set Sankey diagram options", select the impact category "Human toxicity - HTP inf" and set the cut-off to 8%.

The result should look like figure 7. You can now see that the process "fungicide, at regional store house (RER)" has the direct contribution of 0.79 kg 1,4 dichlorobenzene eq. and 12.34 kg 1,4 dichlorobenzene eq. including its pre-chain as "Upstream total". The process "o-dichlorobenzene, at pant - RER" with the highest direct contribution is a pre-process for fungicide production.

Product system: Conventional Viticulture Production
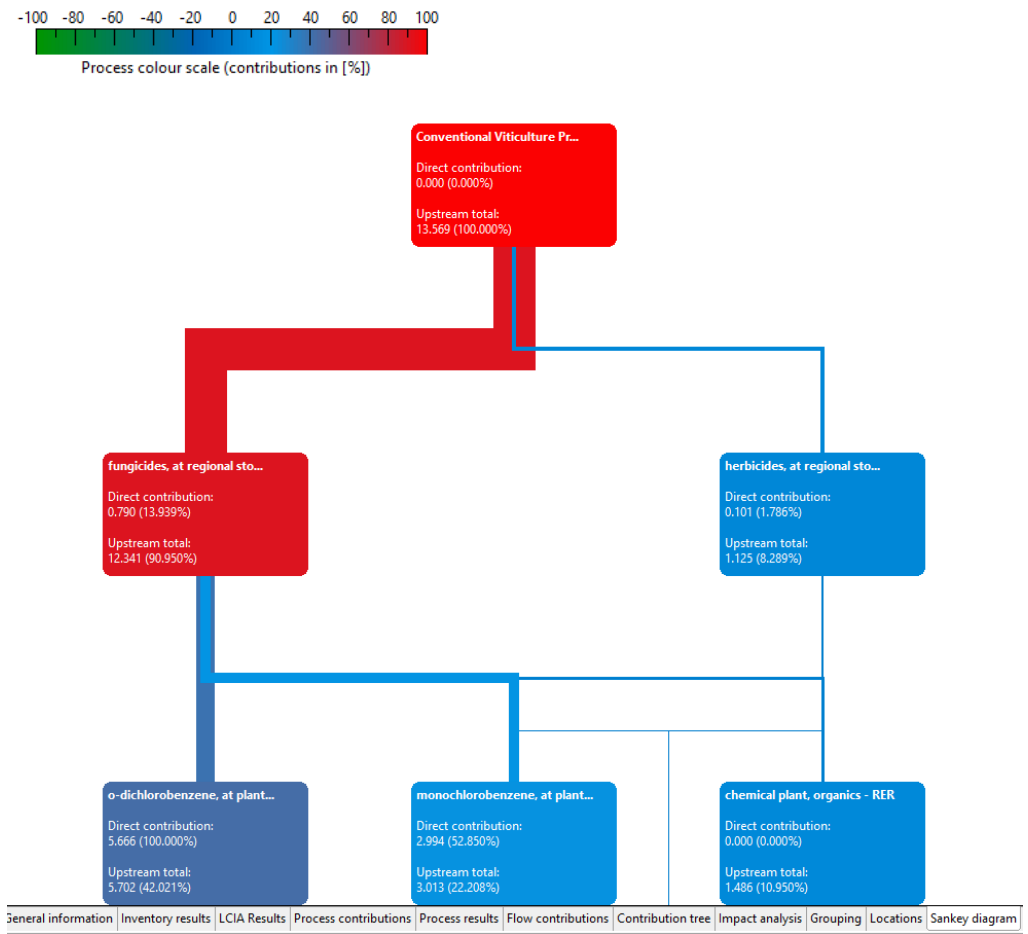Impact category: Human toxicity - HTP inf
Cut-off: 8.000%

-100 -80 -60 -40 -20 0 20 40 60 80 100

Process colour scale (contributions in [%])

Conventional Viticulture Pr...

Direct contribution:
0.000 (0.000%)

Upstream total:
13.569 (100.000%)

fungicides, at regional sto...

Direct contribution:
0.790 (13.939%)

Upstream total:
12.341 (90.950%)

herbicides, at regional sto...

Direct contribution:
0.101 (1.786%)

Upstream total:
1.125 (8.289%)

o-dichlorobenzene, at plant...

Direct contribution:
5.666 (100.000%)

Upstream total:
5.702 (42.021%)

monochlorobenzene, at plant...

Direct contribution:
2.994 (52.850%)

Upstream total:
3.013 (22.208%)

chemical plant, organics - RER

Direct contribution:
0.000 (0.000%)

Upstream total:
1.486 (10.950%)

General information | Inventory results | LCIA Results | Process contributions | Process results | Flow contributions | Contribution tree | Impact analysis | Grouping | Locations | Sankey diagram

Figure 7 Sankey Diagram of the analysis results

6 Sensitivity Analysis

- Calculate the environmental impacts for project "Viticulture - Organic vs ´Conventional Production" with the different impact assessment method "ILCD 2011, midpoint"
- Calculate the environmental impacts for the product system "Conventional Viticulture Production" with the different transport process " transport, tractor and trailer - CH"

To analyse the deviation of the results due to another choice of impact assessment method, go to the project "Viticulture - Organic vs Conventional Production" and change the LCIA method to "ILCA 2011, midpoint" in the LCIA method section.

Select the impact categories of the LCIA methods, which are similar to the impact categories of the LCIA method "CML (baseline)" used in the base case:

• Acidification
• Climate change
• Terrestrial eutrophication
• Freshwater ecotoxicity

openLCA

- Human toxicity – carcinogenics
- Terrestrial ecotoxicity – non-carcinogenics

Save the changes made and calculate the results.

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.

Impact category	Conventional	Organic	Unit
Acidification	4.53087e-2	1.09642e-2	Mole H+ eq.
Climate change	6.64582e+0	2.05849e+0	kg CO2 eq.
Freshwater ecotoxicity	6.10012e+1	2.70661e-1	CTUe
Human toxicity - carcinogenics	3.73290e-7	2.01198e-8	CTUh
Human toxicity - non-carcinogenics	1.65020e-6	3.14936e-8	CTUh
Terrestrial eutrophication	5.52001e-2	4.11216e-2	Mole N eq.

Relative Results

The following chart shows the relative indicator results of the respective project variants. For each indicator, the maximum result is set to 100% and the results of the other variants are displayed in relation to this result.
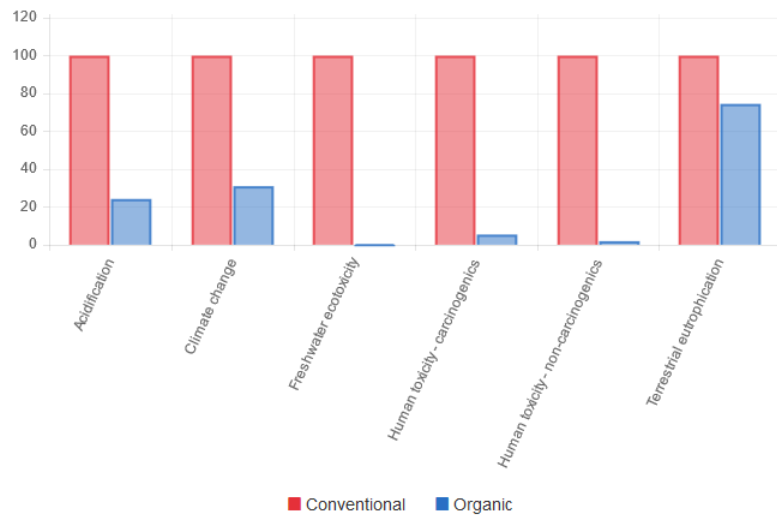

Figure 8 Sensitivity Analysis of the LCIA method for the conventional and organic viticulture production

If you compare figure 3 and 8, you can see that the results are different. The impact categories in both methods are similar, but are based on different reference substances with different units.

To analyse the deviation of results due to another choice of transport, create a copy of the product system "Conventional Viticulture Production" by right clicking on the process in the navigation window and selecting "Copy". Then, right-click on the folder "1.5 Viticulture" and select "Paste". The process "Conventional Viticulture Production (copy)" should now appear in the navigation window. Double click the copied process and rename it "Conventional Viticulture Production - Tractor".

Delete the input flow "transport, lorry 7.5-16t, EUROS - RER" by right clicking the respective flow and selecting "Remove selected". Add the input flow "transport, tractor and trailer - CH", define the provider and consider the same amount (=0.000001 t*248 km). Create a new product system "Conventional Viticulture Production - Tractor "and a new project "Conventional Viticulture Production - Lorry vs Tractor Transport" to compare both options.

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.

Impact category	Conventional - Lorry	Conventional - Tractor	Unit
Acidification potential - average Europe	3.88232e-2	3.88235e-2	kg SO2 eq.
Climate change - GWP100	6.66120e+0	6.66122e+0	kg CO2 eq.
Eutrophication - generic	8.14380e-2	8.14381e-2	kg PO4--- eq.
Freshwater aquatic ecotoxicity - FAETP inf	1.93357e+0	1.93359e+0	kg 1,4-dichlorobenzene eq.
Human toxicity - HTP inf	1.35685e+1	1.35685e+1	kg 1,4-dichlorobenzene eq.
Terrestrial ecotoxicity - TETP inf	6.61696e-2	6.61704e-2	kg 1,4-dichlorobenzene eq.

Relative Results

The following chart shows the relative indicator results of the respective project variants. For each indicator, the maximum result is set to 100% and the results of the other variants are displayed in relation to this result.
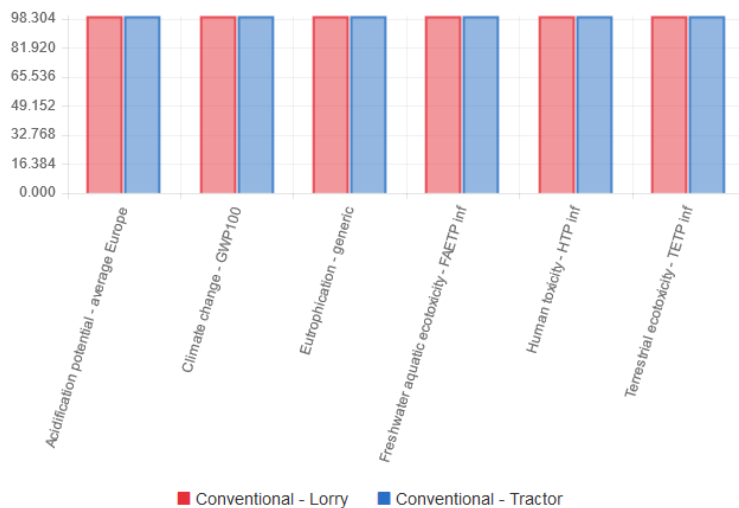

Figure 9 Sensitivity analysis of the transportation for the conventional viticulture production

If you compare both transport options, you can see that the mode of transport barely affects the results of the product system analysed.

7   Basic commands

Table 3 Basic commands in openLCA

Command	Description
Open element	Double click on the element
Copy and paste	Right-click on the element to be duplicated and select "copy", right-click on the folder, in which the copied element should be saved, and select "paste"
Drag and Drop	Adding flows from the navigation window to the to the Input/ Output tab in the process editor or adding processes from the navigation window to the model graph in the product system editor
Filter	Use the filter function for adding new flows to a process or selecting the reference process in a product system
Minimise/maximise element	Use the symbols
Save element	Strg+S or use saving symbol in the main menu
Save image	Right-click in the Editor window and select "Save image"
Search	Use the search function to search any element within the active database
Restore Windows	Go to "Windows" in the main menu and select "Show views" and "Other" or use restore symbol
Number formats	Use a point for floating point numbers, a comma is not accepted

8   Feedback & Contact

If you have other questions not addressed by this document, need further clarifications on any of the points commented, please contact us:

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