ecoinvent v.3.6 in openLCA

Software version: openLCA 1.10.2
Report version: 1
Date: 12 December 2019

Author: Salwa Burhan, Michael Srocka, Andreas Ciroth, Francesca Recanati

GreenDelta GmbH, Kaiserdamm 13, 14057 Berlin, Germany; gd@greendelta.com

GreenDeLTa

Content

Table of figures

1 ecoinvent v.3.6 – What's new?

The latest version of ecoinvent[1] database, version 3.6, released on 12th September 2019 includes major updates, more than 2000 new datasets and 247 new products. Few of the major updates and additions are listed below:[2]

1.1 New and updated datasets

- **Animal husbandry and agriculture sector:** Data on different feeding operations, such as feedlot, pasture, etc. have been covered in version 3.6. Furthermore, data on variety of crops such as sugarcane, soybean, maize, mango and energy wood from Eucalyptus available for different states/regions across Brazil. Additionally, more data on different agricultural products for countries like India and South Africa have been added.
- **Building and construction materials:** New data on bulk construction materials, such as sand and gravel, gypsum, plaster, mortar, bricks, clinker, concrete are available, that are more representative geographically.
- **Chemicals**: New data on production of solar salts, and updated data on vinyl chloride, polyvinylchloride, polyethylene, polypropylene terephthalate have been added.
- **Electricity**: Broadened datasets on electricity, incorporating data for each of the five power grids in Brazil. Electricity data for all countries, except Switzerland have been updated to the 2016, while for Switzerland electricity data provided corresponds to 2017 figures.
- **Petroleum refineries and products:** Over 100 new datasets covering production of a wide range of refined petroleum products, such as diesel, low-sulfur diesel, heavy fuel oil, kerosene, light fuel oil, naphtha, etc. and coal liquefaction are now included in version 3.6.
- **Tourist accommodation:** For the first time ever, data on different tourist accommodation types have been added in the ecoinvent database. These datasets covering hostels, budget hotels as well as luxury hotels are from Brazil and Peru. Consequently, datasets pertaining to various consumer goods linked to the hospitality sector has also been added.
- **Transport**: Significant updates in the transport sector, especially for sea and air transport can be found in version 3.6 of the database. New data on different types of ship types, aircraft types and haul distances, are available.

[1] Wernet, G., Bauer, C., Steubing, B. et al. Int J Life Cycle Assess (2016) 21: 1218. https://doi.org/10.1007/s11367-016-1087-8

[2] Quoted from https://www.ecoinvent.org/files/change_report_v3_6_20190912.pdf (accessed 10.12.2019)

- **Waste treatment and recycling:** Informal recycling practices in countries such as India and Ghana have been included. New datasets include open burning of cables, tyres and electronic appliances, and formal and informal recycling of plastics from e-waste.

1.2 Database-wide changes

- Some of the processes and products have been renamed in version 3.6 of the database. For instance, process - 'jute production, rainfed' from ecoinvent v3.5 is renamed as 'fibre production, jute, retting' in ecoinvent v3.6, product- 'rice' from ecoinvent v3.5 has been changed to 'rice, non-basmati' in ecoinvent v3.6. A list of the changes can be found in the report of changes from the ecoinvent website.
- All the 27 States of Brazil are available as locations now, alongside 5 power grids currently operating in Brazil. This subsequently has an effect on the electricity dependant sector.
- Changes in the allocation based system model, where several products have been classified as non-MFT[3] (material for treatment) which were earlier classified as MFT. Furthermore, prices have been updated/adjusted in this version, which can be found in Annex 1; Documentation of changes implemented in ecoinvent Data 3.6[4].
- Technology level to modern updated for three processes in the consequential system model, namely, 'electricity production, hard coal - PE', 'electricity production, hydro, reservoir, alpine region – PE' and 'electricity production, natural gas, combined cycle power plant – PE'.
- Characterisation factors (CFs) have been updated, and the older version of the LCIA methods are now named obsolete to indicate that no further updates will take place for the obsolete methods. It should be noted that new/renamed elementary flows will not appear in the obsolete method versions.

1.3 Get ecoinvent 3.6 for openLCA

ecoinvent 3.6 is available for download for openLCA exclusively on https://nexus.openlca.org. Please note that versions of ecoinvent 3.6 obtained elsewhere will not be compatible with openLCA. In addition, users with an ecoinvent 3.6 license will also receive access to older versions of ecoinvent. All the different data packs can be used as independent databases in openLCA or combined together, if necessary[5]. However, special attention should be paid to integration of

[3] https://www.ecoinvent.org/support/glossary/glossary-detail.html?&l=m#topic-115

[4] Moreno-Ruiz E., Valsasina L.., FitzGerald D., Brunner F., Symeonidis A., Bourgault G., Wernet G., (2019). Documentation of changes implemented in ecoinvent database v3.6. ecoinvent Association, Zürich, Switzerland.

[5] It is recommended to always import the data pack of smaller size into the bigger one to reduce the time of the import (e.g. unit process data files into LCI data files).

older version of ecoinvent databases with ecoinvent version 3.6 database owing to the changes in the waste modelling approach in openLCA.

Life Cycle Impact Assessment (LCIA) methods package by ecoinvent are available via openLCA Nexus, too. With this package it is possible to reproduce the LCIA results provided by the ecoinvent Association. However, the use of the openLCA LCIA method package with about 40 LCIA methods is also possible.

2 Unique and interesting properties and features of the ecoinvent database

Several aspects are worth being noted about the ecoinvent database. They have been provided also with previous versions of the database. These include:

- three different "system models" which reflect different allocation, cut-off and substitution rules, and rules for modelling end-of-life and recycling
- every process dataset is available as unit process and as system process (with very few exceptions) in each of the three system models;
- a separate documentation, as a short pdf report, is available for each data set
- a correspondence file is provided with changes from previous version to the current version of ecoinvent databases
- costs are provided for all products, with exception of waste flows and products from recycling

For more information about the content and methodology of the ecoinvent v.3.6 database, please check the ecoinvent website, and the report of changes for ecoinvent 3.6 from the ecoinvent website. For current limitations or issues in version 3.6, you can visit the Known Data issues on the ecoinvent website.

3 ecoinvent v.3.6 in openLCA

Ecoinvent v.3.6 is implemented for openLCA 1.10.1. As in previous ecoinvent 3 versions, six data packs generated by the ecoinvent Centre from the undefined ecoinvent database are provided containing the three different system models, all as unit and aggregated (system[6]) processes:

- APOS, allocation at the point of substitution: *"The APOS system model follows the attributional approach in which burdens are attributed proportionally to specific processes."*

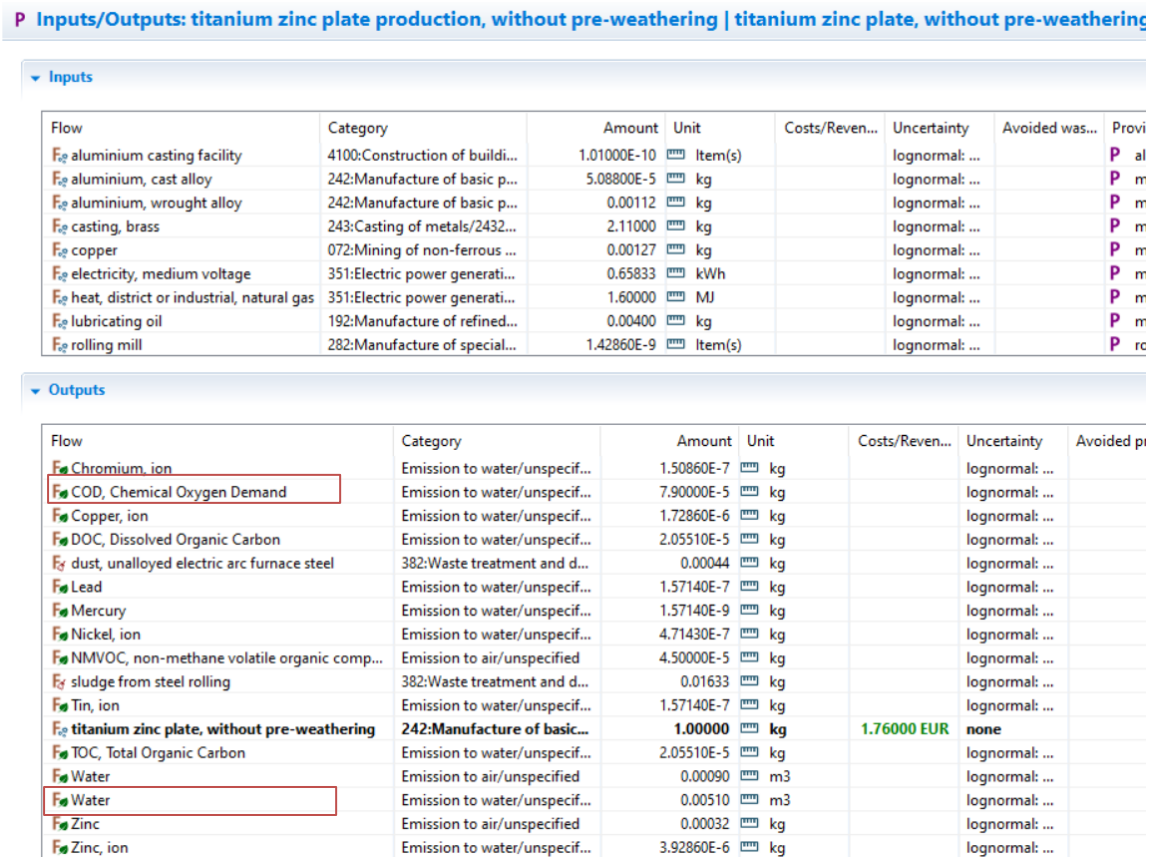
[6] Named "LCI" in the data files

- Cut-Off, allocation cut-off by classification: *"The underlying philosophy is that a producer is fully responsible for the disposal of its wastes, and that he does not receive any credit for the provision of any recyclable materials."*
- Consequential: *"The consequential system model uses different basic assumptions to assess the consequences of a change in an existing system."*

System models in ecoinvent version 3 are explained in detail on the ecoinvent website.

3.1 ecoinvent 3.6 regionalised

In the non-regionalised versions of ecoinvent, elementary flows in the inventory of a process are generic and not assigned to a specific location (Figure 1). In the regionalised versions of ecoinvent, some elementary flows in the inventory of a process are region-specific as indicated by codes[7] for the names of countries, dependent territories, and special areas of geographical interest.



P Inputs/Outputs: titanium zinc plate production, without pre-weathering | titanium zinc plate, without pre-weathering

Inputs

Flow	Category	Amount	Unit	Costs/Reven...	Uncertainty	Avoided was...	Provi
aluminium casting facility	4100:Construction of buildi...	1.01000E-10	Item(s)		lognormal: ...		P al
aluminium, cast alloy	242:Manufacture of basic p...	5.08800E-5	kg		lognormal: ...		P m
aluminium, wrought alloy	242:Manufacture of basic p...	0.00112	kg		lognormal: ...		P m
casting, brass	243:Casting of metals/2432...	2.11000	kg		lognormal: ...		P m
copper	072:Mining of non-ferrous ...	0.00127	kg		lognormal: ...		P m
electricity, medium voltage	351:Electric power generati...	0.65833	kWh		lognormal: ...		P m
heat, district or industrial, natural gas	351:Electric power generati...	1.60000	MJ		lognormal: ...		P m
lubricating oil	192:Manufacture of refined...	0.00400	kg		lognormal: ...		P m
rolling mill	282:Manufacture of special...	1.42860E-9	Item(s)		lognormal: ...		P rc

Outputs

Flow	Category	Amount	Unit	Costs/Reven...	Uncertainty	Avoided pr
Chromium, ion	Emission to water/unspecif...	1.50860E-7	kg		lognormal: ...	
COD, Chemical Oxygen Demand	Emission to water/unspecif...	7.90000E-5	kg		lognormal: ...	
Copper, ion	Emission to water/unspecif...	1.72860E-6	kg		lognormal: ...	
DOC, Dissolved Organic Carbon	Emission to water/unspecif...	2.05510E-5	kg		lognormal: ...	
dust, unalloyed electric arc furnace steel	382:Waste treatment and d...	0.00044	kg		lognormal: ...	
Lead	Emission to water/unspecif...	1.57140E-7	kg		lognormal: ...	
Mercury	Emission to water/unspecif...	1.57140E-9	kg		lognormal: ...	
Nickel, ion	Emission to water/unspecif...	4.71430E-7	kg		lognormal: ...	
NMVOC, non-methane volatile organic comp...	Emission to air/unspecified	4.50000E-5	kg		lognormal: ...	
sludge from steel rolling	382:Waste treatment and d...	0.01633	kg		lognormal: ...	
Tin, ion	Emission to water/unspecif...	1.57140E-7	kg		lognormal: ...	
titanium zinc plate, without pre-weathering	**242:Manufacture of basic...**	**1.00000**	**kg**	**1.76000 EUR**	**none**	
TOC, Total Organic Carbon	Emission to water/unspecif...	2.05510E-5	kg		lognormal: ...	
Water	Emission to air/unspecified	0.00090	m3		lognormal: ...	
Water	Emission to water/unspecif...	0.00510	m3		lognormal: ...	
Zinc	Emission to air/unspecified	0.00032	kg		lognormal: ...	
Zinc, ion	Emission to water/unspecif...	3.92860E-6	kg		lognormal: ...	

Figure 1: ecoinvent v3.6 unit process; cut-off system model

Region specific elementary flows allow usage of region-specific characterisation/impact factors present in the Life Cycle Impact Assessment methods (e.g. water flows assigned to water scarce

[7] https://en.wikipedia.org/wiki/ISO_3166-1

countries have a different impact factor compared to water flows assigned to countries where water is abundant; Figure **2**).

P Inputs/Outputs: titanium zinc plate production, without pre-weathering | titanium zinc plate, without pre-weatheri

Inputs

Flow	Category	Amount	Unit	Costs/Reven...	Uncertainty	Avoided was...	Pr
aluminium casting facility	4100:Construction of buildi...	1.01000E-10	Item(s)		lognormal: ...		P
aluminium, cast alloy	242:Manufacture of basic p...	5.08800E-5	kg		lognormal: ...		P
aluminium, wrought alloy	242:Manufacture of basic p...	0.00112	kg		lognormal: ...		P
casting, brass	243:Casting of metals/2432...	2.11000	kg		lognormal: ...		P
copper	072:Mining of non-ferrous ...	0.00127	kg		lognormal: ...		P
electricity, medium voltage	351:Electric power generati...	0.65833	kWh		lognormal: ...		P
heat, district or industrial, natural gas	351:Electric power generati...	1.60000	MJ		lognormal: ...		P
lubricating oil	192:Manufacture of refined...	0.00400	kg		lognormal: ...		P
rolling mill	282:Manufacture of special...	1.42860E-9	Item(s)		lognormal: ...		P

Outputs

Flow	Category	Amount	Unit	Costs/Reven...	Uncertainty	Avoid
Chromium, ion	Emission to water/unspecif...	1.50860E-7	kg		lognormal: ...	
COD, Chemical Oxygen Demand, DE	Emission to water/unspecif...	7.90000E-5	kg		lognormal: ...	
Copper, ion	Emission to water/unspecif...	1.72860E-6	kg		lognormal: ...	
DOC, Dissolved Organic Carbon	Emission to water/unspecif...	2.05510E-5	kg		lognormal: ...	
dust, unalloyed electric arc furnace steel	382:Waste treatment and d...	0.00044	kg		lognormal: ...	
Lead	Emission to water/unspecif...	1.57140E-7	kg		lognormal: ...	
Mercury	Emission to water/unspecif...	1.57140E-9	kg		lognormal: ...	
Nickel, ion	Emission to water/unspecif...	4.71430E-7	kg		lognormal: ...	
NMVOC, non-methane volatile organic compo...	Emission to air/unspecified	4.50000E-5	kg		lognormal: ...	
sludge from steel rolling	382:Waste treatment and d...	0.01633	kg		lognormal: ...	
Tin, ion	Emission to water/unspecif...	1.57140E-7	kg		lognormal: ...	
titanium zinc plate, without pre-weathering	**242:Manufacture of basic...**	**1.00000**	**kg**	**1.76000 EUR**	**none**	
TOC, Total Organic Carbon	Emission to water/unspecif...	2.05510E-5	kg		lognormal: ...	
Water	Emission to air/unspecified	0.00090	m3		lognormal: ...	
Water, DE	Emission to water/unspecif...	0.00510	m3		lognormal: ...	
Zinc	Emission to air/unspecified	0.00032	kg		lognormal: ...	

Figure 2: ecoinvent v3.6 regionalized unit process; cut-off system model

3.2 Waste modelling for ecoinvent v3.6 in openLCA

It is now possible to use material flow logic approach for end-of-life modelling in ecoinvent v3.6. The wastes (e.g. waste paperboard) in the datasets in ecoinvent now appear as waste flows → as can be seen in Figure 3. A waste flow that is output of a process p1 and input of a waste treatment process p2 can simply be modelled as such: as output of p1, and as input into p2 (!).

The earlier versions of ecoinvent contain waste as product flows with negative amounts and appearing in the opposite exchanges (Figure 4), which required users to follow this "double negative" modelling (negative amounts and switched input and output side for waste "producing" and waste treating process) even for their own processes. This is a common, counter-intuitive topic in LCA trainings, and a source for mistakes when only one side of the process links are set negative. This new, more intuitive waste flow modelling is available directly in the openLCA version of ecoinvent 3.6, for all system models.

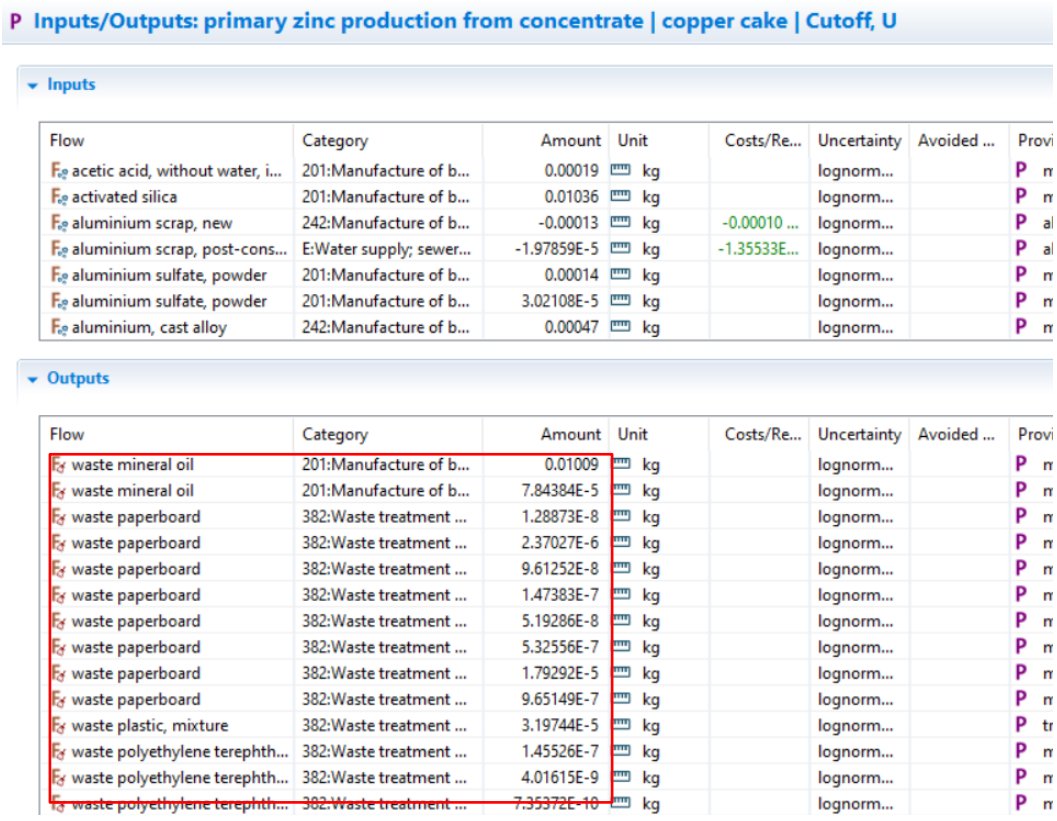


Figure 3: ecoinvent v3.6 database with wastes in material flow logic

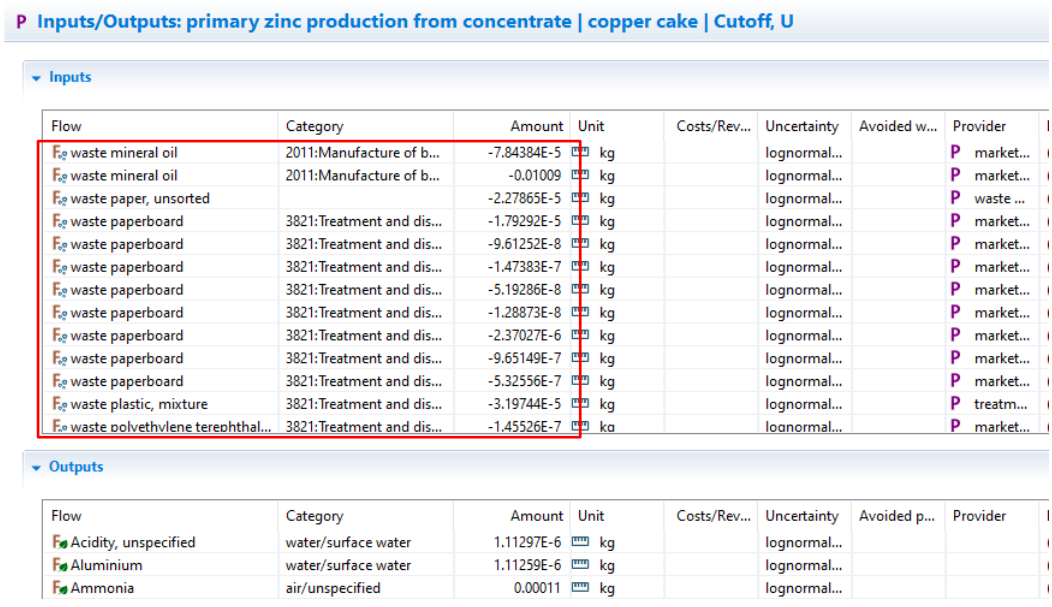


Figure 4: ecoinvent v3.5 database with wastes in the opposite direction approach

When migrating a version 3.5 (or older, from 3.3) versions of ecoinvent to 3.6, or product systems and own models that follow the old "double negative" waste flow logic, the modelling needs to be changed. To do so, **use openLCA version 1.10.2** or higher. Open the database with the old "double negative" waste flow logic, open the python developer window in openLCA and enter therein the script below:

```
from org.openlca.io.ecospold2.input import WasteFlows
WasteFlows.map(db)
```

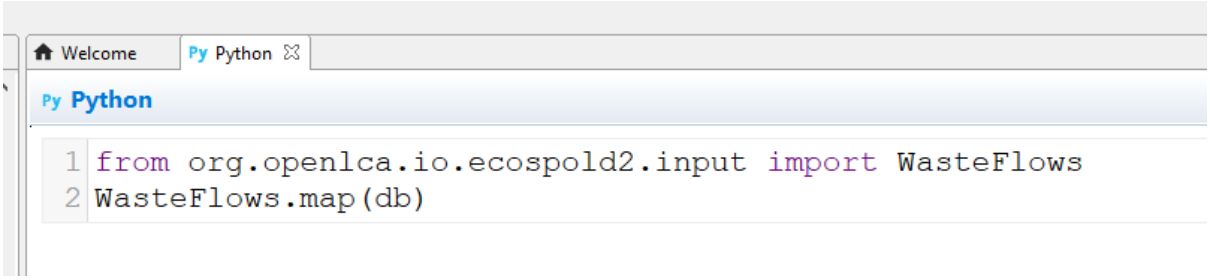


Figure 5: To open python developer window, go to Tools --> Developer tools --> Python

Then execute the script ,  wait for it to finish, then export the elements you want to export, in JSON-LD, and import these in the ecoinvent 3.6. database, of the same, or fitting, system model.

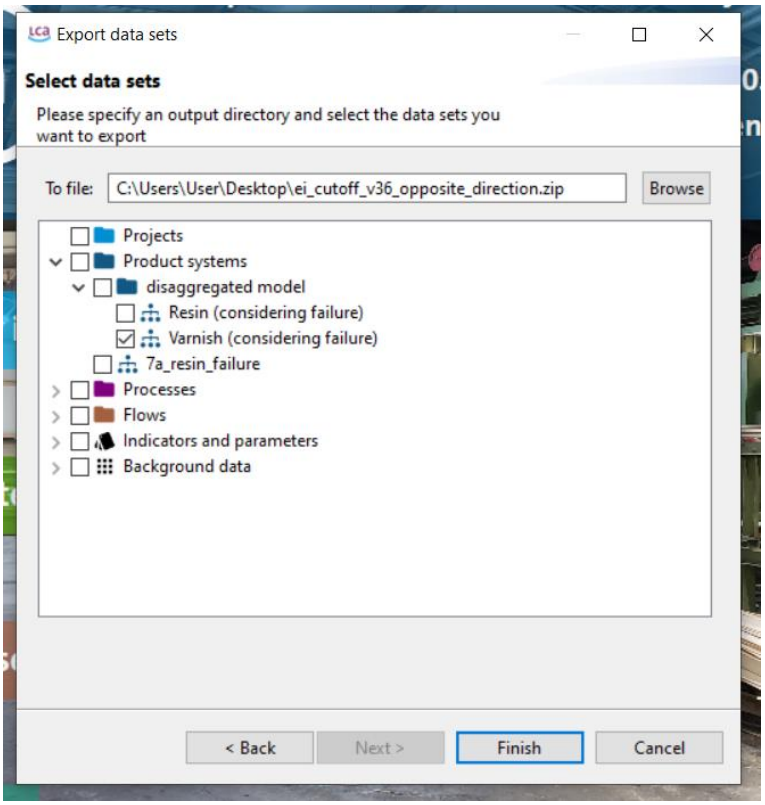


Figure 6: Export window in openLCA

Please be aware that the structure of ecoinvent 3.5 and 3.6 is quite different, due to the new processes added e.g., so it is often advised to start the own model new in ecoinvent 3.6.

Similarly, to reverse to the double negative waste flow modelling, open the database with the new waste flow logic, open the python developer window in openLCA and enter therein the script below:

```
from org.openlca.io.ecospold2.input import WasteFlows
WasteFlows.unmap(db)
```

Figure 7: Run the script to reverse the waste flow logic to 'double negative' waste flow

When importing the product system into a previous version of ecoinvent database, open the ecoinvent database into which you want to import the exported JSON-LD data by double-clicking on it. Right-click onto the database and select *Import*. Select the *Linked Data (JSON-LD)* import wizard and click *Next* (Figure **8**). Choose the directory where the JSON-LD .zip file which you would like to import is saved and select it in the right column. Click on *Next* to open the import settings and select *Never update a data set that already exists* (Figure **9**).

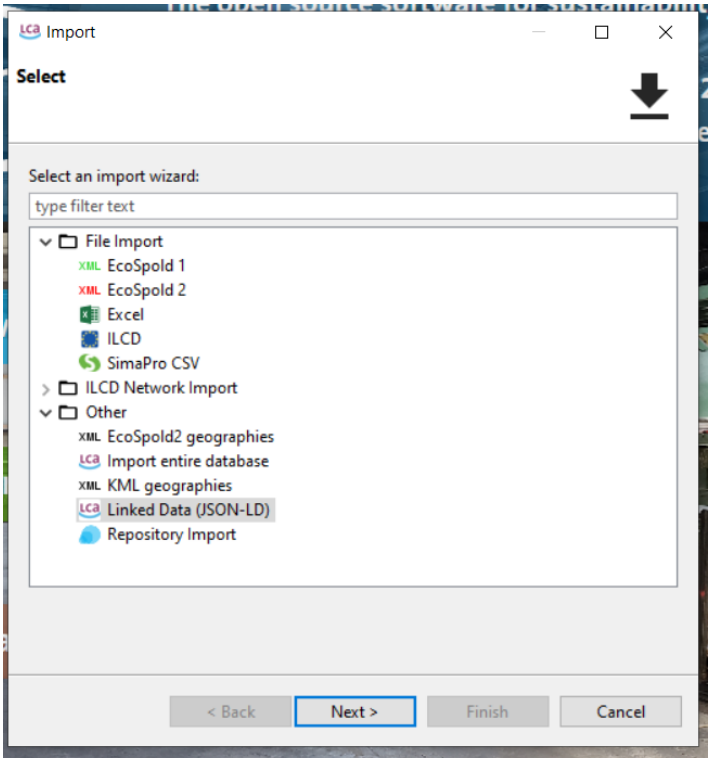


Figure 8: Right-click onto an open database in openLCA to open an import wizard

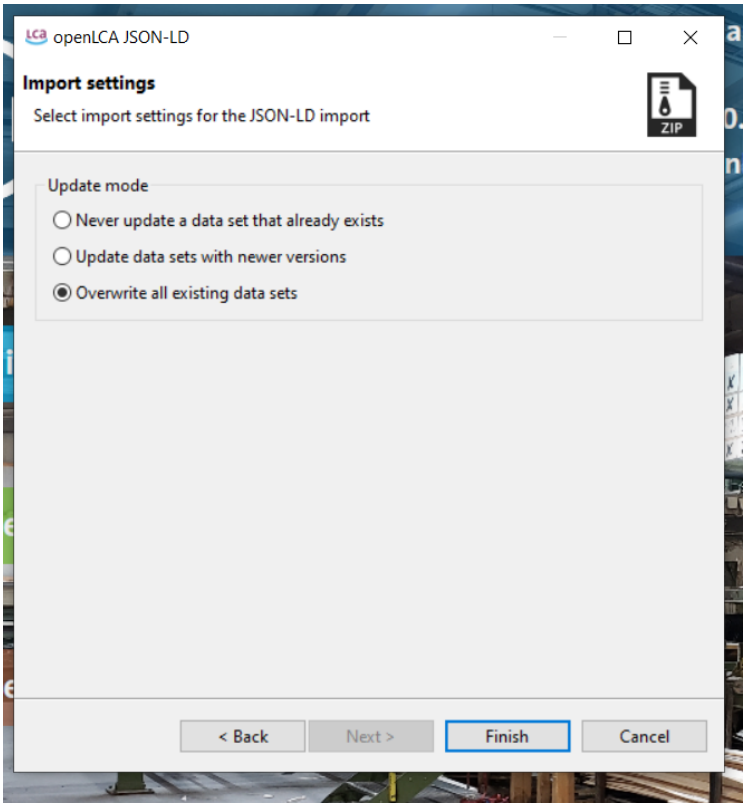


Figure 9: Select Never update a data set that already exists in the import settings

3.3 Addition and extension of price data

As in the previous ecoinvent 3.5 version, the price information for all the intermediate exchanges provided by ecoinvent 3.6 database were extended during the implementation in openLCA so that all exchanges of products with price data had the correspondent cost/revenue specified. As in previous versions of ecoinvent, the prices are provided per product, and do not differ across different processes or also across different countries. This implies that the prices are the same for unit and system processes, and thus, for system processes, do not reflect life cycle costs but "merely" prices.

openLCA includes an advanced **Life Cycle Costing** feature which, allows you to calculate the net added value and the life cycle costs of ecoinvent product systems, using e.g., the price data of products included in ecoinvent v.3.6. For further details on how to perform such calculations, please check the manual "Life Cycle Costing in openLCA" available in the openLCA website.

3.4 Compatibility and quality assurance

ecoinvent 3.6 for openLCA has been thoroughly tested and found to be 100% compatible to the official ecoinvent results without any constraints. The inventory and impact assessment results calculated for product systems using unit process datasets in openLCA were compared to the

LCI and LCIA results published by the ecoinvent Association. The LCI results obtained in openLCA were found to be almost equal to the ecoinvent system processes.

3.5 Memory requirements

With an increased ecoinvent database size, the new product systems in openLCA typically have about almost 15,000 processes and more than 350,000 connections. This can be seen when enabling the "statistics" sheet for product systems (Figure **10Error! Reference source not found.**). When working with ecoinvent 3.6 in openLCA, it is recommended to increase the maximum permitted memory usage of openLCA. This enables smoother and faster calculation of product systems for ecoinvent databases. Visit https://ask.openLCA.org for instructions[8].

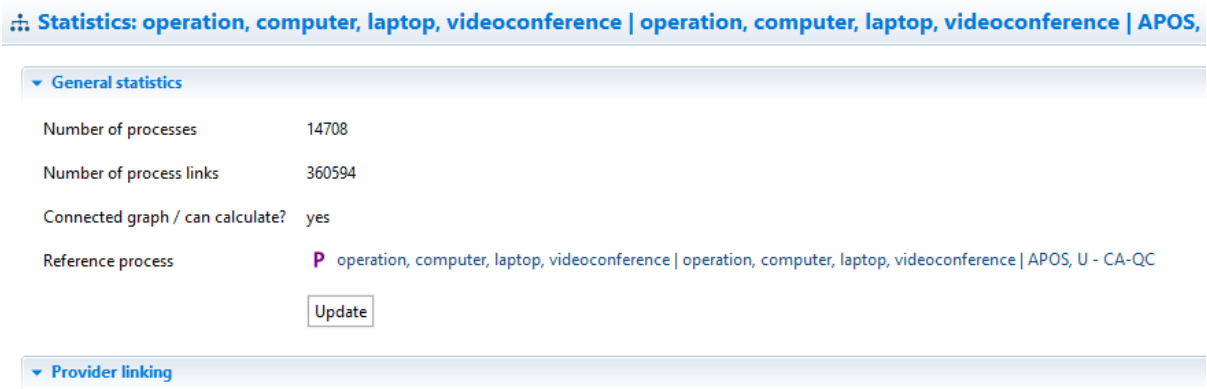


Figure 10. Statistics for the product system created for operation, computer, laptop, videoconference in ecoinvent_apos_v3.6

openLCA is able to handle these systems efficiently, which means an acceptable calculation time, and also memory requirements; however, to calculate a full model, **8GB of RAM** should be available. It is recommended to increase the maximum memory usage of openLCA, which can be done in File→ Settings→ Configuration → Maximum memory usage in MB (Figure **11**).

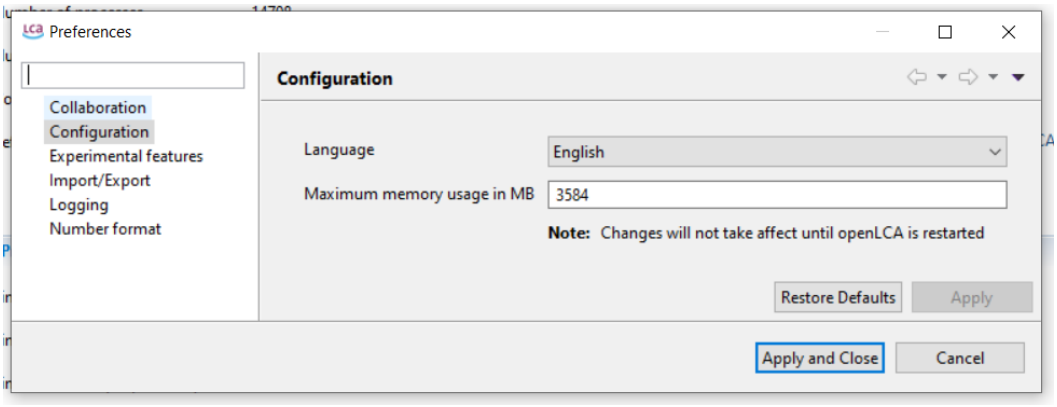


Figure 11: Allocating more memory to openLCA

[8] https://ask.openlca.org/594/how-to-assign-more-memory-to-openlca?show=594

If this is not possible, openLCA allows to specify a **cut-off when creating the product system**, which both reduces the number of processes and the number of connections (and also the result, of course, but for smaller cut-offs the impact should not be dramatic. You can control the impact by checking the system process result.

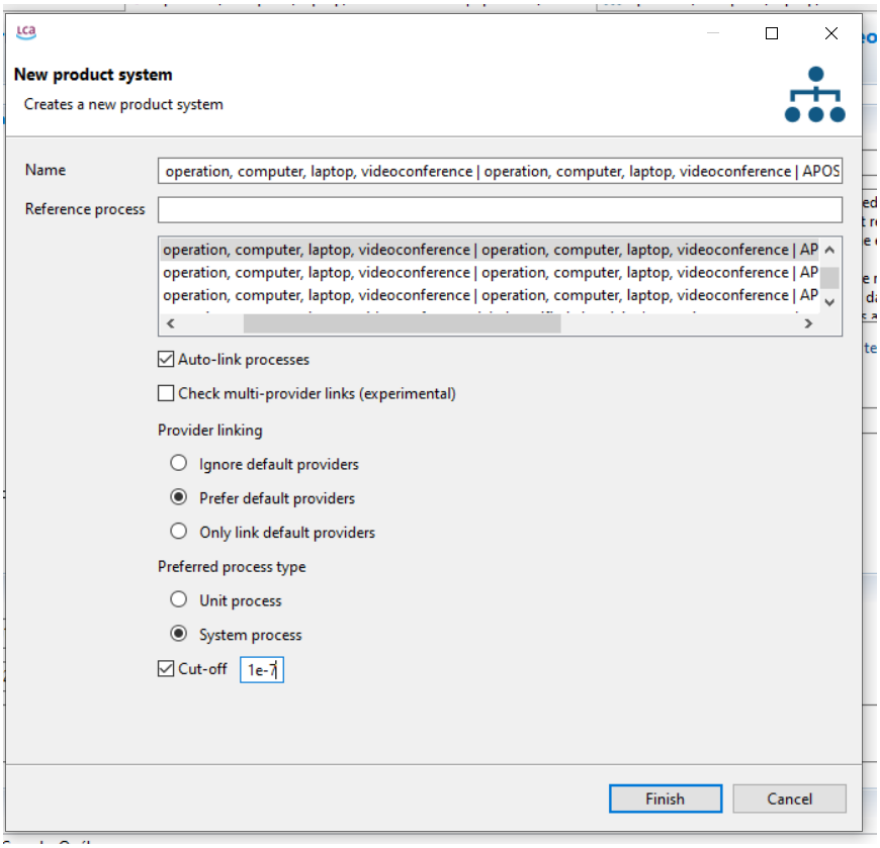


Figure 12. Setting cut-off while creating a product system

3.6 Calculation Libraries

OpenLCA version 1.10.2 (and higher) now can use faster calculation libraries available via GitHub, that uses much less memory and has a much faster execution time, for the quick calculation. Users should download the one of the zip files within the red box in Figure **13** below, for their operating system, unzip the file, and simply paste it in the openLCA installation folder. The library is ready for use.

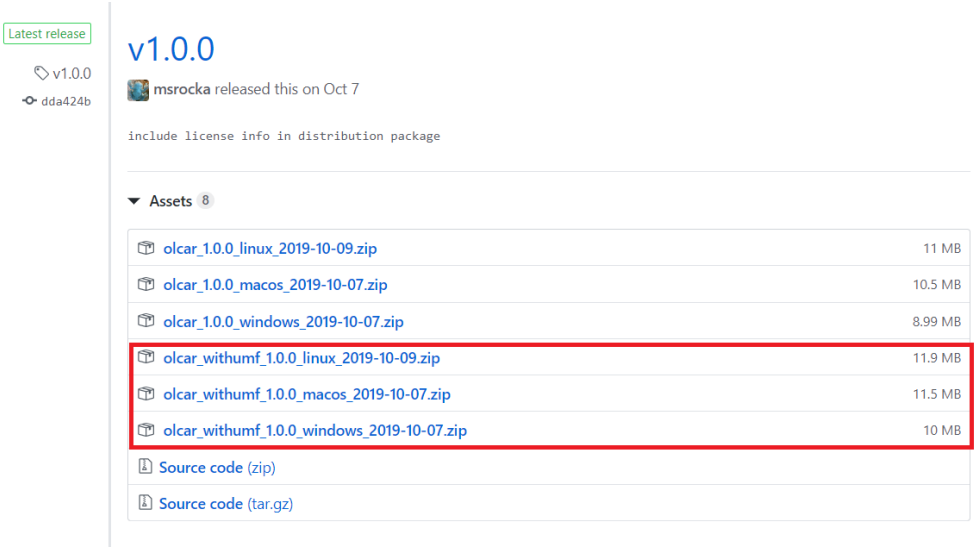


Figure 13: Zip files for importing calculation libraries in openLCA

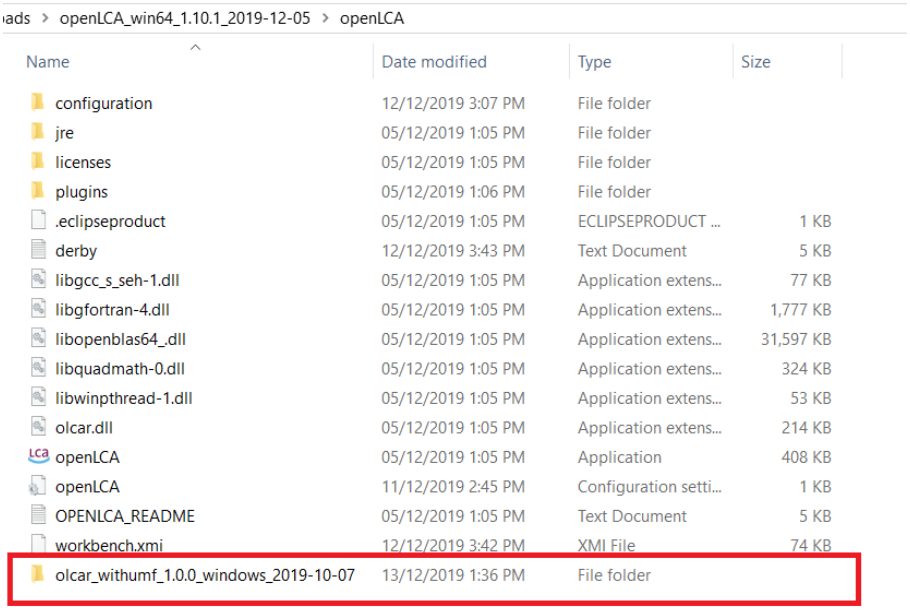


Figure 14: Copy the unzipped folder in the openLCA installation folder; highlighted in red

4 Support

GreenDelta GmbH, developer of openLCA, offers openLCA users prioritised and guaranteed professional openLCA support via the GreenDelta helpdesk: https://www.openlca.org/service-contracts/. Public (*User2User*) support for openLCA is available via https://ask.openlca.org/.

In case you have other questions not addressed by this report, need further clarifications on any of the points commented, or have comments about the ecoinvent v.3.6 database in openLCA, please contact us.