ecoinvent v.3.8 in openLCA

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1 ecoinvent v.3.8 – What's new?

The latest version of the ecoinvent database, version 3.8, released on 21st September 2021 includes major updates and 360 new processes (datasets), 700 updated datasets and 50 new products. A few of the major updates and additions are listed below:[1]

1.1 New and updated datasets

- **Brazilian data:** Due to a project between Brazilian business network for LCA (REDE ACV) and the ecoinvent association, the available data in the previous ecoinvent version was updated and completed, providing a regionalised Life Cycle Inventory (LCI) for Brazil. The main sectors covered by this project are the ones related to crude petroleum oil and natural gas, biodiesel production, diesel distribution, and transportation by lorry.
- **Agriculture:** Some new products were included (e. g. lentil and peas). Many processes for Canada were updated based on data obtained from the University of British Columbia and Food Systems PRISM Laboratory.
- **Batteries:** Datasets created by the Swiss Federal Laboratories for Materials Science and Technology (EMPA) for three different types of batteries (NCA, NMC111, NMC811 Li-ion batteries) divided into their components were included.
- **Chemicals & Plastics:** Through a collaboration with PlasticsEurope, ecoinvent updated the data for styrene production. A cooperation with EUROPUR resulted in updated and new datasets for polyurethane foam production.
- **Electricity:** For most countries, the attributional data was updated to 2018, while for US and Canada, the updated information refers to 2019. For Switzerland, the transformation from high to medium and from medium to low voltage and their losses were updated. These updates were performed due to a collaboration between the ecoinvent association and ETH Zurich and the Paul Scherrer Institute (PSI).
- **Electronics:** New electronic device datasets (e. g. tablets) are also available. The supply chain and its respective components are also adjusted according to the identified needs. In addition, new datasets for printed wiring boards and liquid crystal displays are also included.
- **Forestry and wood-based products:** New data (elaborated due to the collaboration between ecoinvent association, ETH and the International Organization for Bamboo and Rattan INBAR) regarding bamboo forestry and related products were included.

[1] Slightly modified from https://ecoinvent.org/wp-content/uploads/2021/09/Change-Report-v3.8.pdf (accessed 10.11.2021).

- **Metals:** Datasets related to metals were provided by EMPA, and they were included in the ecoinvent database. For example, the production of beryllium, ferroniobium, and scandium oxide from rare earth tailings was included. Other processes were updated (e. g. production of ferrochromium, lithium carbonate, strontium sulfate, tantalum, titanium, and mining of heavy mineral sands), and region-specific values are added for some datasets as copper concentrate smelting.
- **Transport:** Air freight datasets for transport are updated due to a collaboration with INFRAS. As main modifications, the consumption of kerosene and the emissions can be highlighted.
- **Resource correction for biogenic carbon:** A new elementary flow ('Carbon dioxide, non-fossil, resource correction') is added for some processes available in the cut-off database in order to restore the biogenic carbon balances after the allocation process.

1.2 Database-wide changes

- Some of the processes and products have been renamed in version 3.8 of the database. For example, for the process 'compact fluorescent lamp' from ecoinvent v3.7.1 is renamed to 'compact fluorescent lamp production' in ecoinvent v3.8. The product 'compact fluorescent bulb' from ecoinvent v3.7.1 has been changed to 'compact fluorescent lamp' in ecoinvent v3.8. A list of the changes can be found in the report of changes from the ecoinvent website[2].
- Characterisation factors (CFs) have been updated/implemented. For example, for the IPCC 2013 indicator GWP 100a, the CF of the flow 'VOC, volatile organic compounds, unspecified origin' was updated from 3.9762 to 4.5. For the new flow included for the Cut-off database ('Carbon dioxide, non-fossil, resource correction'), the correspondent CFs were also added to the methods. The complete ecoinvent method package is available for openLCA, while the openLCA method package has also been updated in order to include the new elementary flows and their characterisation factors (for compatible methods)[3].
- ecoinvent 3.8 also includes a new system model 'allocation, cut-off, EN15804', which allows the EPD practitioners to comply with the EN15804&A2:2019 standard. In addition, according to the ecoinvent association, "the new system model contributes to a harmonisation in the calculation of the indicators of the standard. The system model is fully compliant with ISO 14025, ISO 21930 and EN15804&A2:2019. It provides all Life Cycle Inventory (LCI) indicators required by the aforementioned standards and adheres to the end-of-waste criteria set by the European Commission". This system model is not yet available for openLCA.

[2] From https://ecoinvent.org/wp-content/uploads/2021/09/Change-Report-v3.8.pdf (accessed 19.11.2021).

[3] From https://ecoinvent.org/wp-content/uploads/2021/09/Change-Report-v3.8.pdf (accessed 19.11.2021).

- To facilitate the calculation of the emissions of electricity following the Scope 2 and Scope 3 Guidance of the GHG protocol, a spreadsheet ('electricity emission factors – scope 2 – 3.xlsx') is available online[4] containing the separated emission factors (kg of CO2 equivalent/ kWh of electricity) calculated under the IPCC's AR5 report from 2013, applying the global warming potential values.

1.3 Get ecoinvent 3.8 for openLCA

ecoinvent 3.8 is available for download for openLCA exclusively on https://nexus.openlca.org. Please note that versions of ecoinvent 3.8 obtained elsewhere will not be compatible with openLCA. The ecoinvent licence purchased via nexus.openLCA is downward compatible.

In addition, users with an ecoinvent 3.8 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 integrating older versions of ecoinvent databases with ecoinvent version 3.8 database due to the modification of the REF_ID (or UUID) of some processes and flows. For more information, please check section 4.2.

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 is also possible and recommended by GreenDelta.

2 Unique and interesting properties and features of the ecoinvent database

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

- three different "system models" that reflect different allocation, cut-off and substitution rules, and rules for modelling end-of-life and recycling, besides the new "allocation, cut-off, EN15804", not yet released by GreenDelta

[4] From https://v38.ecoquery.ecoinvent.org/File/Files (accessed 19.11.2021).

[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).

- every process dataset is available as a unit process and as a system process (with very few exceptions) in each of the system models
- separate documentation is available for each data set, and the link to this information can be found in openLCA software, under Process → General Information → Description (last sentence)
- a correspondence file is provided with changes from the previous version to the current version of ecoinvent databases
- costs/revenues provided by ecoinvent are included in the database, except for waste flows and products from recycling

For more information about the content and methodology of the ecoinvent v.3.8 database, please check the ecoinvent website (https://ecoinvent.org/), and the report of changes[6] for ecoinvent 3.8 from the ecoinvent website. For current limitations or issues in version 3.8, you can visit the Known Issues[7] on the ecoinvent website.

3 ecoinvent v.3.8 in openLCA

ecoinvent v.3.8 APOS, Consequential, and Cut-off are implemented for openLCA 1.10.3. As in the previous ecoinvent 3 versions, data packs generated by the ecoinvent Centre from the undefined ecoinvent database are provided containing the different system models, all as unit and aggregated (system[8]) processes:

- **Allocation at the Point of Substitution:** "The system model 'allocation at the point of substitution' is also known as the APOS system model. It follows an attributional approach in which the responsibility over wastes (burdens) are shared between producers and subsequent users benefiting of the treatment processes by using valuable products generated in these."[9]
- **Allocation cut-off by classification:** "The system model 'allocation, cut-off by classification', or the cut-off system model, is based on the recycled content, or cut-off, approach. In this system model, wastes are the producer's responsibility ('polluter pays'), and there is an incentivisation to use recyclable products, that are available burden free (cut-off)."[10]

[6] From https://ecoinvent.org/wp-content/uploads/2021/09/Change-Report-v3.8.pdf (accessed 19.11.2021).

[7] See https://ecoinvent.org/the-ecoinvent-database/data-releases/ecoinvent-3-8/#!/known-issues.

[8] Named "LCI" in the data files.

[9] From https://ecoinvent.org/the-ecoinvent-database/system-models/#!/allocation (accessed 19.11.20021).

[10] From https://ecoinvent.org/the-ecoinvent-database/system-models/#!/allocation-cut-off (accessed 19.11.2021)

- **Substitution, consequential, long-term:** "The system model 'substitution, consequential, long-term' is also known as the consequential system model. This model uses different basic assumptions to assess the consequences of a change in an existing system. It applies substitution to credit processes with the avoided burdens from supply chains that are replaced by the by-products generated within them."[11]

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

3.1 ecoinvent 3.8 regionalised

Besides the data packs provided by ecoinvent, GreenDelta also prepared a regionalised version of the database (only for the unit process database). 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[12] for the names of countries, dependent territories, and particular areas of geographical interest. Region-specific elementary flows allow usage of region-specific characterisation/impact factors in Life Cycle Impact Assessment methods (e. g. Ammonia flows – emission to air/ low population density; Figure 2).

[11] From https://ecoinvent.org/the-ecoinvent-database/system-models/#!/substitution (accessed 19.11.2021).

[12] From https://en.wikipedia.org/wiki/ISO_3166-1 (accessed 19.11.2021).

Inputs/Outputs: sugar beet production | sugar beet | APOS, U

Inputs

Flow	Category	Amount	Unit	Costs/Re...	Uncertai...	Avoided...	Provider	Data qu...	Descri...
[thio]carbamate-compo...	202:Manufacture o...	4.75891E-6	kg		lognor...		mark...	(2; 2; 5; ...	See ch...
ammonium nitrate	201:Manufacture o...	0.00079	kg		lognor...		mark...	(2; 1; 5; ...	The ex...
ammonium sulfate	201:Manufacture o...	2.10329E-5	kg		lognor...		mark...	(2; 1; 5; ...	See ch...
application of plant prot...	016:Support activit...	5.65925E-5	ha		lognor...		appli...	(2; 1; 5; ...	See ch...
benzimidazole-compou...	202:Manufacture o...	7.71717E-6	kg		lognor...		mark...	(2; 2; 5; ...	See ch...
Carbon dioxide, in air	Resource/in air	0.35233	kg		lognor...			(2; 1; 5; ...	Model...
cyclic N-compound	202:Manufacture o...	1.92929E-6	kg		lognor...		mark...	(2; 2; 5; ...	See ch...
Energy, gross calorific va...	Resource/biotic	3.77322	MJ		lognor...			(2; 1; 5; ...	
fertilising, by broadcaster	016:Support activit...	5.14477E-5	ha		lognor...		fertili...	(2; 1; 5; ...	See ch...
fodder loading, by self-l...	016:Support activit...	2.60968E-5	m3		lognor...		fodd...	(2; 1; 5; ...	See ch...
green manure, Swiss inte...	016:Support activit...	1.28620E-5	ha		lognor...		green...	(2; 1; 5; ...	See ch...
harvesting, by complete ...	016:Support activit...	1.28620E-5	ha		lognor...		harve...	(2; 1; 5; ...	See ch...
hoeing	016:Support activit...	2.57239E-5	ha		lognor...		hoein...	(2; 1; 5; ...	See ch...

Outputs

Flow	Category	Amount	Unit	Costs/Re...	Uncertai...	Avoided...	Provider	Data qu...	Descri...
Ammonia	Emission to air/lo...	0.00020	kg		lognor...			(2; 2; 5; ...	Model...
biowaste	382:Waste treatme...	0.00333	kg		none		mark...		['Biow...
Cadmium	Emission to soil/a...	-4.26194E-8	kg		none				Model...
Cadmium, ion	Emission to water/...	3.91972E-10	kg		lognor...			(2; 2; 5; ...	Model...
Cadmium, ion	Emission to water/...	2.84353E-10	kg		lognor...			(2; 2; 5; ...	Model...
Carbon dioxide, fossil	Emission to air/lo...	0.00015	kg		lognor...			(2; 2; 5; ...	Model...
Chlorothalonil	Emission to soil/a...	9.00336E-7	kg		lognor...			(2; 2; 5; ...	Model...
Chromium	Emission to soil/a...	-3.42565E-7	kg		none				Model...
Chromium, ion	Emission to water/...	2.33533E-7	kg		lognor...			(2; 2; 5; ...	Model...
Chromium, ion	Emission to water/...	4.01371E-8	kg		lognor...			(2; 2; 5; ...	Model...
Copper	Emission to soil/a...	-1.86897E-6	kg		none				Model...
Copper, ion	Emission to water/...	4.47249E-8	kg		lognor...			(2; 2; 5; ...	Model...

Figure 1: ecoinvent v3.8 unit process (sugar beet production | sugar beet | APOS, U – CH); APOS system model

Inputs/Outputs: sugar beet production | sugar beet | APOS, U

Inputs

Flow	Category	Amount	Unit	Costs/Re...	Uncertai...	Avoided...	Provider	Data qu...	Descri...
[thio]carbamate-compo...	202:Manufacture o...	4.75891E-6	kg		lognor...		mark...	(2; 2; 5; ...	See ch...
ammonium nitrate	201:Manufacture o...	0.00079	kg		lognor...		mark...	(2; 1; 5; ...	The ex...
ammonium sulfate	201:Manufacture o...	2.10329E-5	kg		lognor...		mark...	(2; 1; 5; ...	See ch...
application of plant prot...	016:Support activit...	5.65925E-5	ha		lognor...		appli...	(2; 1; 5; ...	See ch...
benzimidazole-compou...	202:Manufacture o...	7.71717E-6	kg		lognor...		mark...	(2; 2; 5; ...	See ch...
Carbon dioxide, in air	Resource/in air	0.35233	kg		lognor...			(2; 1; 5; ...	Model...
cyclic N-compound	202:Manufacture o...	1.92929E-6	kg		lognor...		mark...	(2; 2; 5; ...	See ch...
Energy, gross calorific va...	Resource/biotic	3.77322	MJ		lognor...			(2; 1; 5; ...	
fertilising, by broadcaster	016:Support activit...	5.14477E-5	ha		lognor...		fertili...	(2; 1; 5; ...	See ch...
fodder loading, by self-l...	016:Support activit...	2.60968E-5	m3		lognor...		fodd...	(2; 1; 5; ...	See ch...
green manure, Swiss inte...	016:Support activit...	1.28620E-5	ha		lognor...		green...	(2; 1; 5; ...	See ch...
harvesting, by complete ...	016:Support activit...	1.28620E-5	ha		lognor...		harve...	(2; 1; 5; ...	See ch...
hoeing	016:Support activit...	2.57239E-5	ha		lognor...		hoein...	(2; 1; 5; ...	See ch...

Outputs

Flow	Category	Amount	Unit	Costs/Re...	Uncertai...	Avoided...	Provider	Data qu...	Descri...
Ammonia, CH	Emission to air/lo...	0.00020	kg		lognor...			(2; 2; 5; ...	Model...
biowaste	382:Waste treatme...	0.00333	kg		none		mark...		['Biow...
Cadmium	Emission to soil/a...	-4.26194E-8	kg		none				Model...
Cadmium, ion	Emission to water/...	3.91972E-10	kg		lognor...			(2; 2; 5; ...	Model...
Cadmium, ion	Emission to water/...	2.84353E-10	kg		lognor...			(2; 2; 5; ...	Model...
Carbon dioxide, fossil	Emission to air/lo...	0.00015	kg		lognor...			(2; 2; 5; ...	Model...
Chlorothalonil	Emission to soil/a...	9.00336E-7	kg		lognor...			(2; 2; 5; ...	Model...
Chromium	Emission to soil/a...	-3.42565E-7	kg		none				Model...
Chromium, ion	Emission to water/...	2.33533E-7	kg		lognor...			(2; 2; 5; ...	Model...
Chromium, ion	Emission to water/...	4.01371E-8	kg		lognor...			(2; 2; 5; ...	Model...
Copper	Emission to soil/a...	-1.86897E-6	kg		none				Model...
Copper, ion	Emission to water/...	4.47249E-8	kg		lognor...			(2; 2; 5; ...	Model...

Figure 2: ecoinvent v3.8 regionalised unit process (sugar beet production | sugar beet | APOS, U – CH); APOS system model

3.2 Modifications in the structure of the database: Elementary flows and Methods

The compartments and subcompartments of the elementary flows of ecoinvent database and openLCA follow slightly different structures. Hence, aiming to achieve a better organisation of the database when it is applied together with openLCA methods, the categories/folders of the openLCA elementary flows is applied. This means that the names of the compartments and subcompartments of ecoinvent elementary flows were modified, according to Table 1. The same organisation was applied for the correspondence of the characterisation factors of the flows applied to both method packages.

Table 1: Equivalent openLCA and ecoinvent compartments

ECOINVENT COMPARTMENT	CORRESPONDENT OPENLCA COMPARTMENT	ECOINVENT SUBCOMPARTMENT	CORRESPONDENT OPENLCA SUBCOMPARTMENT
air	Emission to air	urban air close to ground	high population density
air	Emission to air	indoor	indoor
air	Emission to air	non-urban air or from high stacks	low population density
air	Emission to air	low population density, long-term	low population density, long-term
air	Emission to air	lower stratosphere + upper troposphere	lower stratosphere + upper troposphere
air	Emission to air	unspecified	unspecified
soil	Emission to soil	agricultural	agricultural
soil	Emission to soil	forestry	forestry
soil	Emission to soil	industrial	industrial
soil	Emission to soil	unspecified	unspecified
water	Emission to water	ground-	ground water
water	Emission to water	ground-, long-term	ground water, long-term
water	Emission to water	ocean	ocean
water	Emission to water	surface water	surface water
water	Emission to water	unspecified	unspecified
natural resource	Resource	biotic	biotic
natural resource	Resource	in air	in air
natural resource	Resource	in ground	in ground
natural resource	Resource	in water	in water
natural resource	Resource	land	land
natural resource	Resource	unspecified	unspecified

While implementing ecoinvent database, it was observed that some elementary flows were already available in openLCA methods with a different REF_ID (UUID), leading to duplicated flows when the ecoinvent database is applied together with the openLCA method package. For this reason, the REF_IDs of some ecoinvent elementary flows applied only in the exchanges (and not in the methods) were replaced according to Table 2, allowing that the same elementary flows are applied both in the methods and in the exchanges.

Table 2: Modification of REF_ID of elementary flows

OLD REF_ID	NEW REF_ID
340AA83E-9594-5819-9E0E-D149BEC71BCF	160e9149-1279-403c-b340-29320098fe24
6D1613A4-9AF4-5BB3-B159-AC480EE22C7E	9b7517da-bb9d-4e28-ad22-176545b1f684
FBEEE113-C3BF-5981-9519-0C9FDC12CCB4	7d42cef0-9fb3-4559-963d-f88c0878eb45
8F159C78-3969-53C1-BA65-2692D66A5A4B	1c811963-1b64-4b38-ae23-5a2180619545
5F271F8E-85C1-579B-A84B-656E0ECD815A	4de7a01b-6b25-47ea-ac3f-503d7dc80dbe
8AA28904-C1A5-5634-AC89-D9E6A6F06864	3463068f-1c9c-4c3d-a71b-928fd53a2778
DBEE28EF-19AA-518C-BA95-BCABC680C02D	b06657cc-7229-4ff9-8bcd-0d313c2d4ee1
6252488A-5C44-596C-9E69-EAC3F5CBCDA4	40f20171-eb6f-4f58-821f-b0ce55f8c14f
E29F6C49-884E-50FC-90A6-1AC6E862D72D	648dd9c6-7e45-43cb-a1cf-a6bf9f8f6031
9975947B-6720-5B2C-9361-CB1706BC2C46	0af54a93-77c7-388b-988b-892362f371c7
6A868660-04A2-5C62-9860-73A1E29305B9	bf86d447-9792-45cb-97d0-e97ff0e2e817
66BB79B7-E919-5A20-8EE6-DAC7BAE45E91	133b38fd-4034-4495-bba8-0d2bd7394dcc
83605D14-94D7-57E3-AF9B-8CB347AFD5E0	58461761-87fc-4059-b541-5045f3ab7bc7
E5FA0589-D03F-5179-BC91-5C4B69F79BAC	c5c25aa6-d630-40bd-bed7-4e718c877ef4
A6F022BE-E24E-5D56-898E-98D4074C594F	6982a662-940c-493b-a4eb-6ae6b93cfcc9
3F2346BC-AD14-45F3-953E-D1B675D5E78E	b61006af-446a-43fc-b717-c089e8ea131f
1CC0BE91-3DF0-5D9B-BA9E-C0BB9CE30B0D	59911bb2-5a76-475b-adaf-ec02d8c0d4ff
5CB4EB1D-CF64-51F6-88A3-BB2B2B8109F7	d58afcee-81ee-427b-b44b-953c4deda2e0
110975E5-1BCD-51AB-9B87-246CFB417C55	c79c2a8d-bafe-4725-9b3a-bf79df1b53f2
D49B5E5B-135D-536F-8231-81AB53F28022	d1891870-f763-4b58-9142-47d99710a220
80F5619C-57F9-5D9F-8214-651A4D9CE805	a20bde8a-6f75-4a5b-83d0-e5b370790cc9
A5632D26-8338-5A18-B12B-1B6E085EB7B0	f9296b67-b074-4450-a2d0-62d2da068f32
A5562EC3-69EA-52E6-94BF-312D3F022A50	e637cf57-9edd-4adb-85d3-b79e2b0b1779
A22EB638-A8E7-50FC-A2A6-C13DA880621C	2854713c-bc52-4e10-848a-ebe76d4d6ec6
9F2356AE-88BA-5222-899F-9532001BE831	fb186f3f-511a-4751-be1e-42ddbc947a0d
D2060AA6-F2E8-5D8E-973A-54DD7BAB6754	db95797b-4a84-468b-939b-194a6cd4458a
A19626DC-F58A-5F51-9800-FC86AAD103DC	57513e61-fc79-4f38-bab3-62de2d9d04ba
6D1ECED4-E8DF-510F-AA95-0C5B9686DEE3	b240919a-c1d8-4cc7-b058-b0814c262c0c
BCDAB235-4B5C-5935-95D3-B75643C38377	3c775fde-d83d-46c1-b3dc-257f33dbe04c
B2901848-11F6-55D9-AD94-7E087982A739	58f8a955-859d-4c54-81c8-1d851b738984
5DCD3CE5-E5ED-5BE5-8FDE-257D3E56F297	b96076ad-ecb8-4fd6-a42d-a8ed8c84194c
5676C9BE-E0AE-5E3C-B768-E54C580C4911	796ed953-1cc3-49b2-b464-ef931eb8f01f
30A6DD59-5D2B-5C4C-A6A3-9A3BD8DED2C9	88f5012c-5f64-4dd4-a3dc-30f603d74b79
D718A4E6-87FF-532C-82C2-8EC16F00DDFE	b356de7f-1399-4c15-a895-5975632b3a49
41BF091C-DAE0-51A3-A4E9-04FA9527DE6A	3537983f-5c9c-41ea-98a0-339fa8c54017
CB98ECF7-0C27-5BB0-9980-07ED7D15431E	64bda5cb-e043-4b5d-8da4-af69011a2672
A971E173-869C-57D8-916E-2B711893BBD9	8dff6b8d-6ed0-4092-bb27-5a8213bb9d10

Moreover, the new elementary flows (comparing ecoinvent 3.7.1 APOS database and 3.8 APOS database) were identified, and the characterisation factors of these flows obtained from the ecoinvent LCIA implementation file were added to the previous openLCA method package (2.1.1) for the compatibles method/category in openLCA 2.1.1 method package. Therefore, the new version of the openLCA methods (2.1.2) should be applied together with ecoinvent 3.8. Table 3 lists the correspondent openLCA method and indicator to the ecoinvent ones, for which it was needed to include new CFs.

Regarding the methods provided directly by ecoinvent (provided separately by GreenDelta), all the impact categories/characterisation factors and remaining details were maintained and provided as a separate method package. In addition, it was identified that some new flows that are only part of the methods are not applied as exchanges (inputs, outputs of the processes). For this reason, they were not previously available in the database. Therefore, these flows were added to the database, and then their CFs were also included in the new version of ecoinvent and openLCA method package available for the user. For the openLCA method package, these CFs were only included when compatible methods/indicators (i.e., with the same or equivalent units) were identified, as available in Table 4.

Table 3: Correspondence of ecoinvent and openLCA methods and indicators

ECOINVENT METHOD	ECOINVENT CATEGORY	ECOINVENT INDICATOR	OPENLCA METHODS	OPENLCA INDICATOR
CML V4.8 2016	material resources: metals/minerals	abiotic depletion potential (ADP): elements (ultimate reserves)	CML-IA baseline	Abiotic depletion
EF V3.0	ecotoxicity: freshwater, organics	comparative toxic unit for ecosystems (CTUe)	EF 3.0 Method (adapted)	Ecotoxicity, freshwater - organics
EF V3.0	human toxicity: non-carcinogenic	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, non-cancer
EF V3.0	human toxicity: non-carcinogenic, organics	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, non-cancer - organics
EF V3.0	ecotoxicity: freshwater	comparative toxic unit for ecosystems (CTUe)	EF 3.0 Method (adapted)	Ecotoxicity, freshwater
EF V3.0	human toxicity: carcinogenic, organics	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, cancer - organics
EF V3.0	human toxicity: carcinogenic	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, cancer
EF V3.0	material resources: metals/minerals	abiotic depletion potential (ADP): elements (ultimate reserves)	EF 3.0 Method (adapted)	Resource use, minerals and metals
EF V3.0 EN15804	ecotoxicity: freshwater	comparative toxic unit for ecosystems (CTUe)	EN 15804 +A2 Method	Ecotoxicity, freshwater
EF V3.0 EN15804	human toxicity: non-carcinogenic	comparative toxic unit for human (CTUh)	EN 15804 +A2 Method	Human toxicity, non-cancer
EF V3.0 EN15804	human toxicity: carcinogenic	comparative toxic unit for human (CTUh)	EN 15804 +A2 Method	Human toxicity, cancer
EF V3.0 EN15804	material resources: metals/minerals	abiotic depletion potential (ADP): elements (ultimate reserves)	EN 15804 +A2 Method	Resource use, minerals and metals

Table 4: Correspondence of ecoinvent and openLCA methods and indicators

ECOINVENT METHOD	ECOINVENT CATEGORY	ECOINVENT INDICATOR	OPENLCA METHOD	OPENLCA CATEGORY/INDICATOR	OPENLCA UNITS	ECOINVENT UNITS
CML V4.8 2016	climate change	GWP 100a	CML-IA baseline	Global warming (GWP100a)	kg CO2 eq	kg CO2-Eq
CML V4.8 2016	ecotoxicity: freshwater	freshwater aquatic ecotoxicity (FAETP inf)	CML-IA baseline	Fresh water aquatic ecotox.	kg 1,4-DB eq	kg 1,4-DCB-Eq
CML V4.8 2016	ecotoxicity: marine	marine aquatic ecotoxicity (MAETP inf)	CML-IA baseline	Marine aquatic ecotoxicity	kg 1,4-DB eq	kg 1,4-DCB-Eq
CML V4.8 2016	ecotoxicity: terrestrial	terrestrial ecotoxicity (TETP inf)	CML-IA baseline	Terrestrial ecotoxicity	kg 1,4-DB eq	kg 1,4-DCB-Eq
CML V4.8 2016	human toxicity	human toxicity (HTP inf)	CML-IA baseline	Human toxicity	kg 1,4-DB eq	kg 1,4-DCB-Eq
CML V4.8 2016	photochemical oxidant formation	photochemical oxidation (high NOx)	CML-IA baseline	Photochemical oxidation	kg C2H4 eq	kg ethylene-Eq
ECOLOGICAL SCARCITY 2013	water pollutants	total	Ecological Scarcity 2013	Water pollutants	UBP	UBP
ECOLOGICAL SCARCITY 2013	pesticides into soil	total	Ecological Scarcity 2013	Pesticides into soil	UBP	UBP
ECOLOGICAL SCARCITY 2013	land use	total	Ecological Scarcity 2013	Land use	UBP	UBP
ECOLOGICAL SCARCITY 2013	mineral resources	total	Ecological Scarcity 2013	Mineral resources	UBP	UBP
ECOLOGICAL SCARCITY 2013	main air pollutants and PM	total	Ecological Scarcity 2013	Main air pollutants and PM	UBP	UBP
ECOLOGICAL SCARCITY 2013	POP into water	total	Ecological Scarcity 2013	POP into water	UBP	UBP
ECOLOGICAL SCARCITY 2013	global warming	total	Ecological Scarcity 2013	Global warming	UBP	UBP
ECOSYSTEM DAMAGE POTENTIAL	total	linear, land transformation	Ecosystem Damage Potential	linear, land transformation	points	points
ECOSYSTEM DAMAGE POTENTIAL	total	linear, land occupation	Ecosystem Damage Potential	linear, land occupation	points	points
EDIP2003	human toxicity	via soil	EDIP 2003	Human toxicity soil	m3	m3 soil
EDIP2003	human toxicity	via surface water	EDIP 2003	Human toxicity water	m3	m3 water
EDIP2003	global warming	GWP 100a	EDIP 2003	Global warming 100a	kg CO2 eq	kg CO2-Eq
EDIP2003	ecotoxicity	chronic, in soil	EDIP 2003	Ecotoxicity soil chronic	m3	m3 soil

ECOINVENT METHOD	ECOINVENT CATEGORY	ECOINVENT INDICATOR	OPENLCA METHOD	OPENLCA CATEGORY/INDICATOR	OPENLCA UNITS	ECOINVENT UNITS
EDIP2003	ecotoxicity	chronic, in water	EDIP 2003	Ecotoxicity water chronic	m3	m3 water
EDIP2003	ecotoxicity	acute, in water	EDIP 2003	Ecotoxicity water acute	m3	m3 water
EDIP2003	photochemical ozone formation	impacts on human health	EDIP 2003	Ozone formation (Human)	person.ppm.h	person.ppm.h
EDIP2003	photochemical ozone formation	impacts on vegetation	EDIP 2003	Ozone formation (Vegetation)	m2.ppm.h	m2.ppm.h
EF V3.0 EN15804	climate change	global warming potential (GWP100)	EN 15804 +A2 Method	Climate change	kg CO2 eq	kg CO2-Eq
EF V3.0 EN15804	climate change: land use and land use change	global warming potential (GWP100)	EN 15804 +A2 Method	Climate change - Land use and LU change	kg CO2 eq	kg CO2-Eq
EF V3.0 EN15804	ecotoxicity: freshwater	comparative toxic unit for ecosystems (CTUe)	EN 15804 +A2 Method	Ecotoxicity, freshwater	CTUe	CTUe
EF V3.0 EN15804	human toxicity: carcinogenic	comparative toxic unit for human (CTUh)	EN 15804 +A2 Method	Human toxicity, cancer	CTUh	CTUh
EF V3.0 EN15804	human toxicity: non-carcinogenic	comparative toxic unit for human (CTUh)	EN 15804 +A2 Method	Human toxicity, non-cancer	CTUh	CTUh
EF V3.0 EN15804	land use	soil quality index	EN 15804 +A2 Method	Land use	Pt	dimensionless
EF V3.0 EN15804	photochemical ozone formation: human health	tropospheric ozone concentration increase	EN 15804 +A2 Method	Photochemical ozone formation	kg NMVOC eq	kg NMVOC-Eq
EF V3.0	climate change	global warming potential (GWP100)	EF 3.0 Method (adapted)	Climate change	kg CO2 eq	kg CO2-Eq
EF V3.0	climate change: land use and land use change	global warming potential (GWP100)	EF 3.0 Method (adapted)	Climate change - Land use and LU change	kg CO2 eq	kg CO2-Eq
EF V3.0	ecotoxicity: freshwater	comparative toxic unit for ecosystems (CTUe)	EF 3.0 Method (adapted)	Ecotoxicity, freshwater	CTUe	CTUe
EF V3.0	ecotoxicity: freshwater, inorganics	comparative toxic unit for ecosystems (CTUe)	EF 3.0 Method (adapted)	Ecotoxicity, freshwater - inorganics	CTUe	CTUe
EF V3.0	ecotoxicity: freshwater, metals	comparative toxic unit for ecosystems (CTUe)	EF 3.0 Method (adapted)	Ecotoxicity, freshwater - metals	CTUe	CTUe

ECOINVENT METHOD	ECOINVENT CATEGORY	ECOINVENT INDICATOR	OPENLCA METHOD	OPENLCA CATEGORY/INDICATOR	OPENLCA UNITS	ECOINVENT UNITS
EF V3.0	ecotoxicity: freshwater, organics	comparative toxic unit for ecosystems (CTUe)	EF 3.0 Method (adapted)	Ecotoxicity, freshwater - organics	CTUe	CTUe
EF V3.0	human toxicity: carcinogenic	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, cancer	CTUh	CTUh
EF V3.0	human toxicity: carcinogenic, organics	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, cancer - organics	CTUh	CTUh
EF V3.0	human toxicity: non-carcinogenic	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, non-cancer	CTUh	CTUh
EF V3.0	human toxicity: non-carcinogenic, inorganics	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, non-cancer - inorganics	CTUh	CTUh
EF V3.0	human toxicity: non-carcinogenic, metals	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, non-cancer - metals	CTUh	CTUh
EF V3.0	human toxicity: non-carcinogenic, organics	comparative toxic unit for human (CTUh)	EF 3.0 Method (adapted)	Human toxicity, non-cancer - organics	CTUh	CTUh
EF V3.0	land use	soil quality index	EF 3.0 Method (adapted)	Land use	Pt	dimensionless
EF V3.0	photochemical ozone formation: human health	tropospheric ozone concentration increase	EF 3.0 Method (adapted)	Photochemical ozone formation	kg NMVOC eq	kg NMVOC-Eq
IPCC 2013	climate change	GWP 100a	IPCC 2013 GWP 100a	IPCC GWP 100a	kg CO_2 eq	kg CO_2-Eq
IPCC 2013	climate change	GWP 20a	IPCC 2013 GWP 20a	IPCC GWP 20a	kg CO_2 eq	kg CO_2-Eq
SELECTED LCI RESULTS, ADDITIONAL	air	carbon monoxide	Selected LCI results, additional	Carbon monoxide	kg	kg
SELECTED LCI RESULTS, ADDITIONAL	air	methane	Selected LCI results, additional	Methane	kg	kg
SELECTED LCI RESULTS	resource	land occupation	Selected LCI results	Land occupation	m2a	m2a
SELECTED LCI RESULTS	air	NMVOC	Selected LCI results	NMVOC	kg	kg

3.3 Modifications in the structure of the database: Processes, Product Flows, and Geographies

ecoinvent processes and flows are organised according to the International Standard Industrial Classification of All Economic Activities (ISIC)[13]. However, the classification is listed as "not available" in the implementation file for some cases. Therefore, for this reason, the same categories/folders applied in the previous versions of the database (3.7.1) provided by GreenDelta were used. For the processes/flows not available on the previous versions of ecoinvent, the folders/categories selected were based on the similarity with other processes in the database.

Regarding the geographies, the list of latitude/longitude of the locations was updated using the latitudes/longitudes available on the files of the geographies for ecoinvent 3.7.1. The codes of the locations were replaced by their extended names to allow better user comprehension (Figure 3).

Figure 3: Locations

3.4 Addition and extension of price data

openLCA includes an advanced Life Cycle Costing feature, which, in addition to the price data of products included in ecoinvent v.3.8, allows you to calculate the net added value and the life cycle costs of ecoinvent product systems. For further details on how to perform such

[13] From https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf (accessed 22.11.2021).

calculations, please check the manual "Life Cycle Costing in openLCA" available in the openLCA website.

3.5 Compatibility and quality assurance

ecoinvent 3.8 for openLCA has been thoroughly tested and found to be 100% compatible 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.

Table 5 lists the LCIA results for an exemplary dataset and the EF v3.0 method. If the openLCA LCIA methods are applied, the results are slightly different due to some modifications in the characterisation factors. The users can also compare it directly using the link added to the original ecoinvent dataset documentation in the description of the processes (Figure 4). For the regionalised databases, the original dataset documentation (provided by ecoinvent for unit processes) was also added. However, as the datasets were prepared by GreenDelta and the location of some elementary flows was added, the results differ from the ecoinvent results for the methods that take these elementary flows with added locations into account.

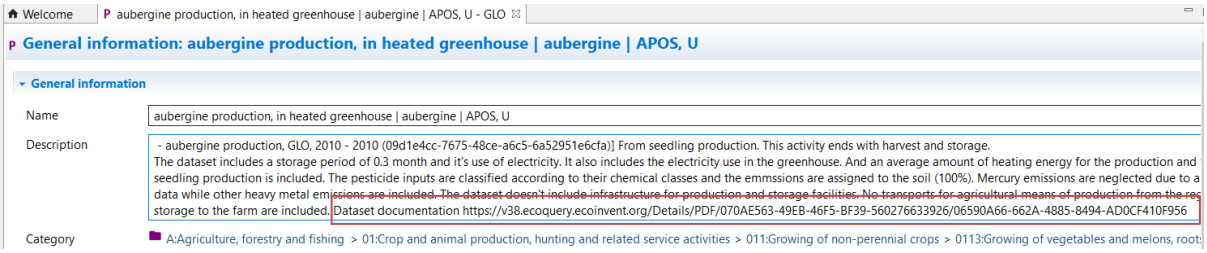

Figure 4: Link containing dataset documentation

Another investigated aspect was the change in results for ecoinvent 3.8 calculations compared to the previous version ecoinvent 3.7.1 for the same process. The addition of more flows to the individual datasets can lead to the increase of LCIA results. In contrast, the updating of outdated datasets can lead to an improvement of these results. The change was therefore investigated for one exemplary dataset that was not specifically updated or newly created. However, changes in the upstream processes might occur, e. g. with regards to the updated energy mixes. The results are displayed in Table 6.

Table 5: Comparison of the results published by the ecoinvent Association with those calculated in openLCA using the LCIA method as provided by ecoinvent

CATEGORY	UNIT	PUBLISHED RESULTS	CALCULATED RESULTS	%
acidification	mol H+-Eq	2.06E-01	2.06E-01	100.0
climate change	kg CO2-Eq	3.86E+01	3.86E+01	100.0
climate change: biogenic	kg CO2-Eq	9.32E-02	9.32E-02	100.0
climate change: fossil	kg CO2-Eq	3.85E+01	3.85E+01	100.0
climate change: land use and land use change	kg CO2-Eq	9.81E-02	9.81E-02	100.0
ecotoxicity: freshwater	CTUe	1.19E+03	1.19E+03	100.0
ecotoxicity: freshwater, inorganics	CTUe	1.71E+02	1.71E+02	100.0
ecotoxicity: freshwater, metals	CTUe	1.00E+03	1.00E+03	100.0
ecotoxicity: freshwater, organics	CTUe	1.53E+01	1.53E+01	100.0
energy resources: non-renewable	MJ, net calorific value	4.92E+02	4.92E+02	100.0
eutrophication: freshwater	kg PO4-Eq	2.38E-02	2.38E-02	100.0
eutrophication: marine	kg N-Eq	5.10E-02	5.10E-02	100.0
eutrophication: terrestrial	mol N-Eq	3.81E-01	3.81E-01	100.0
human toxicity: carcinogenic	CTUh	4.35E-08	4.35E-08	100.0
human toxicity: carcinogenic, inorganics	CTUh	3.33E-16	3.33E-16	100.0
human toxicity: carcinogenic, metals	CTUh	3.83E-08	3.83E-08	100.0
human toxicity: carcinogenic, organics	CTUh	5.14E-09	5.14E-09	100.0
human toxicity: non-carcinogenic	CTUh	1.67E-06	1.67E-06	100.0
human toxicity: non-carcinogenic, inorganics	CTUh	1.08E-07	1.08E-07	100.0
human toxicity: non-carcinogenic, metals	CTUh	1.21E-06	1.21E-06	100.0
human toxicity: non-carcinogenic, organics	CTUh	3.55E-07	3.55E-07	100.0
ionising radiation: human health	kBq U235-Eq	4.85E+00	4.85E+00	100.0
land use	dimensionless	1.01E+02	1.01E+02	100.0
material resources: metals/minerals	kg Sb-Eq	1.44E-03	1.44E-03	100.3
ozone depletion - ozone depletion potential (ODP)	kg CFC-11-Eq	6.06E-06	6.06E-06	100.0
particulate matter formation	disease incidence	1.53E-06	1.53E-06	100.0
photochemical ozone formation: human health	kg NMVOC-Eq	1.11E-01	1.11E-01	100.0
water use	m3 world eq. deprived	1.83E+01	1.83E+01	100.0

Table 6: Comparison of ecoinvent 3.7.1 and 3.8 results for the same exemplary dataset

CATEGORY	UNIT	PUBLISHED RESULTS	CALCULATED RESULTS	%
acidification	mol H+-Eq	0.00579	0.0058	100.2
climate change	kg CO2-Eq	1.01124	1.01082	100.0
climate change: biogenic	kg CO2-Eq	0.00096	0.00096	100.0
climate change: fossil	kg CO2-Eq	1.00979	1.0094	100.0
climate change: land use and land use change	kg CO2-Eq	0.00049	0.00046	93.9
ecotoxicity: freshwater	CTUe	10.10101	10.10127	100.0
ecotoxicity: freshwater, inorganics	CTUe	0.97859	0.98463	100.6
ecotoxicity: freshwater, metals	CTUe	8.91006	8.92354	100.2
ecotoxicity: freshwater, organics	CTUe	0.2567	0.23667	92.2
energy resources: non-renewable	MJ, net calorific value	11.50377	1.18E+01	102.4
eutrophication: freshwater	kg PO4-Eq	0.00025	0.00025	100.0
eutrophication: marine	kg N-Eq	0.00799	0.00799	100.0
eutrophication: terrestrial	mol N-Eq	0.01774	0.01768	99.7
human toxicity: carcinogenic	CTUh	4.59E-10	4.56E-10	99.3
human toxicity: carcinogenic, inorganics	CTUh	2.90E-18	2.79E-18	96.1
human toxicity: carcinogenic, metals	CTUh	3.48E-10	3.41E-10	98.1
human toxicity: carcinogenic, organics	CTUh	1.12E-10	1.15E-10	103.0
human toxicity: non-carcinogenic	CTUh	2.70E-08	2.78E-08	102.9
human toxicity: non-carcinogenic, inorganics	CTUh	1.28E-09	1.29E-09	100.8
human toxicity: non-carcinogenic, metals	CTUh	2.56E-08	2.61E-08	101.8
human toxicity: non-carcinogenic, organics	CTUh	1.83E-10	1.79E-10	97.8
ionising radiation: human health	kBq U235-Eq	0.05591	5.52E-02	98.7
land use	dimensionless	86.77982	85.78641	98.9
material resources: metals/minerals	kg Sb-Eq	1.83E-06	1.81E-06	98.9
ozone depletion - ozone depletion potential (ODP)	kg CFC-11-Eq	1.00E-07	1.02E-07	101.7
particulate matter formation	disease incidence	4.22E-08	4.22E-08	100.1
photochemical ozone formation: human health	kg NMVOC-Eq	0.00265	2.64E-03	99.6
water use	m3 world eq. deprived	1.18433	1.18438	100.0
Average				**99.5**

3.6 Memory requirements

With an increased ecoinvent database size, the new product systems in openLCA typically have about 15,000 processes and about 450,000 connections. This can be seen when enabling the "statistics" sheet for product systems (Figure 5). When working with ecoinvent 3.8 in openLCA, it is recommended to increase the maximum memory usage of openLCA. This enables smoother

and faster calculation of product systems for ecoinvent databases. Visit https://ask.openLCA.org for instructions[14].

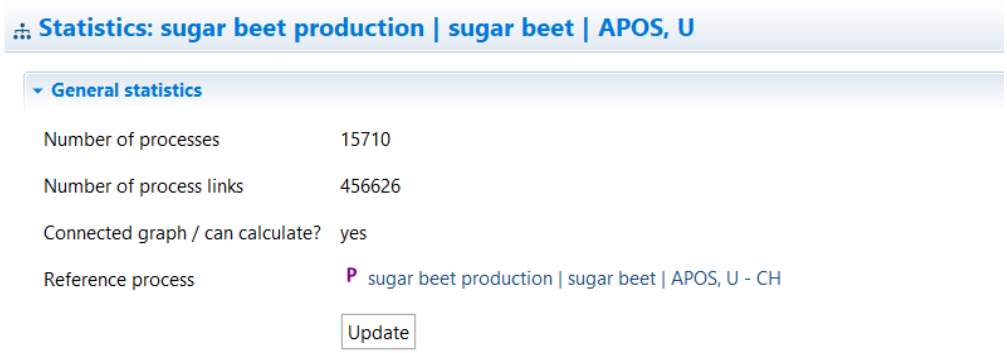

Figure 5: Statistics for the product system created for sugar beet production in ecoinvent_apos_v3.8

openLCA can handle these systems efficiently, which leads to an acceptable calculation time and memory requirements; however, to calculate a full model, **12 GB of RAM** should be available, which means that the 64-bit version of openLCA should be used. 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 6).

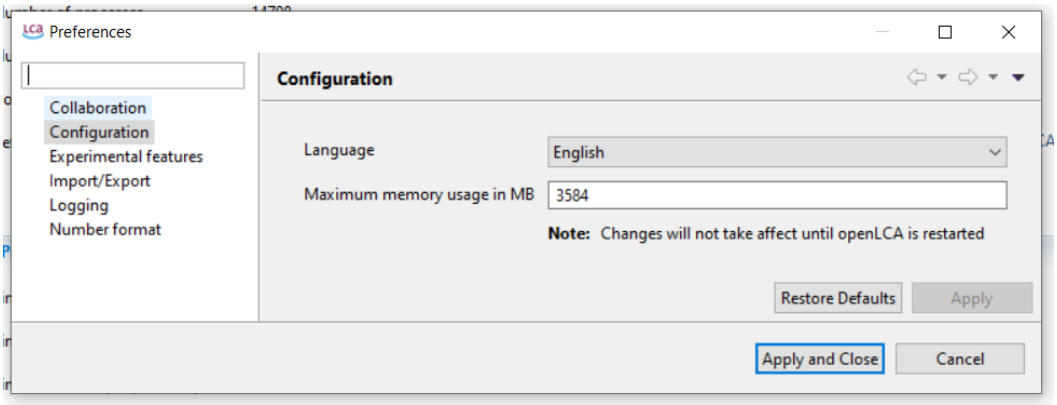

Figure 6: Allocating more memory to openLCA

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 the result, of course, but for smaller cut-offs the impact should not be dramatic). This option is shown in Figure 7. You can control the impact by checking the system process result.

[14] For assignment of memory: https://ask.openlca.org/594/how-to-assign-more-memory-to-openlca?show=594

To show the differences in calculation time from ecoinvent 3.7.1 to ecoinvent 3.8, the calculation time of an exemplary unit process was tested using four different scenarios and four different computers. The LCIA results were calculated using the same LCIA method and the APOS system model. The calculation was performed calculating directly from the process and creating and calculating from the corresponding system model. Additionally, the data quality assessment was included or left out, since it is known to slow down the calculations. The time was measured for the calculation in both the previous version ecoinvent 3.7.1 and the newly implemented version ecoinvent 3.8. The results for ecoinvent 3.8 compared to ecoinvent 3.7.1 are displayed in Figure 8.

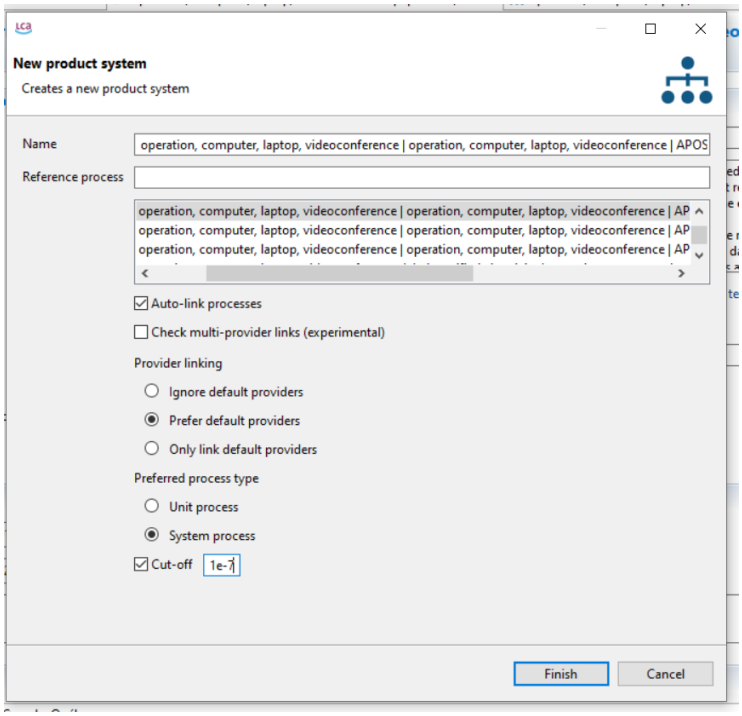

Figure 7: Setting cut-off while creating a product system

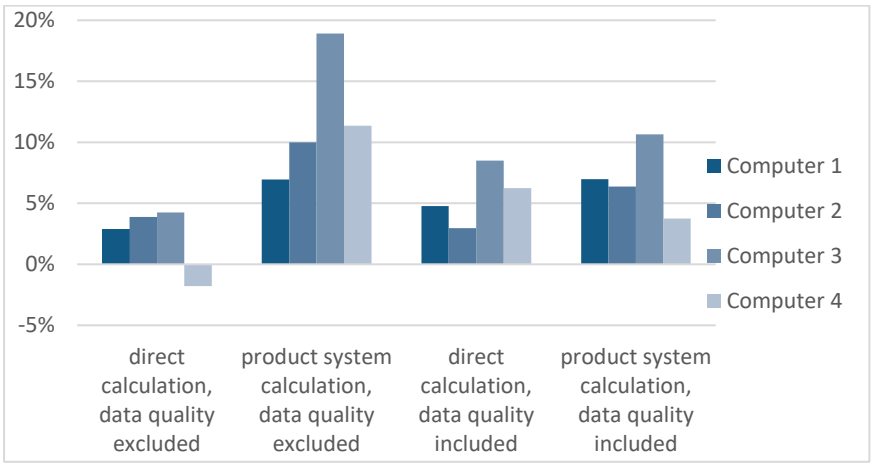

Figure 8: Comparison of calculation times for ecoinvent 3.8 in relation to ecoinvent 3.7.1 (baseline, 0 %)

4 Migrating to ecoinvent 3.8

In order to enable users to import product systems from a previous version of ecoinvent (3.7.1) into the newest version of ecoinvent (3.8) without having to manually re-select all providers, the UUIDs of processes were synchronised among different versions of ecoinvent databases. This allows users to update models by just importing the foreground system from a previous ecoinvent database into a newer version of ecoinvent. Please note that migration will only be supported for ecoinvent databases underlying the same system model (consequential, cut-off, apos) and process selection (unit or system/LCI) and openLCA 1.10.3 must be used.

4.1 Compatibility check between different versions of ecoinvent

To check if two ecoinvent databases in openLCA feature the same REF_ID (UUID) either retrieve this information from the General Information tabs of the processes or via the openLCA SQL Query Browser. For using SQL Query to check the UUID of a process (for e.g. barley grain, feed production, Swiss integrated production | barley grain, feed, Swiss integrated production | Cutoff, U), click on Tools → Developer tools → SQL, and run the following code:

```
select ref_id from tbl_processes where name like '%barley grain, feed production, Swiss integrated production | barley grain, feed, Swiss integrated production%' and f_location = (select id from tbl_locations where code = 'CH')
```

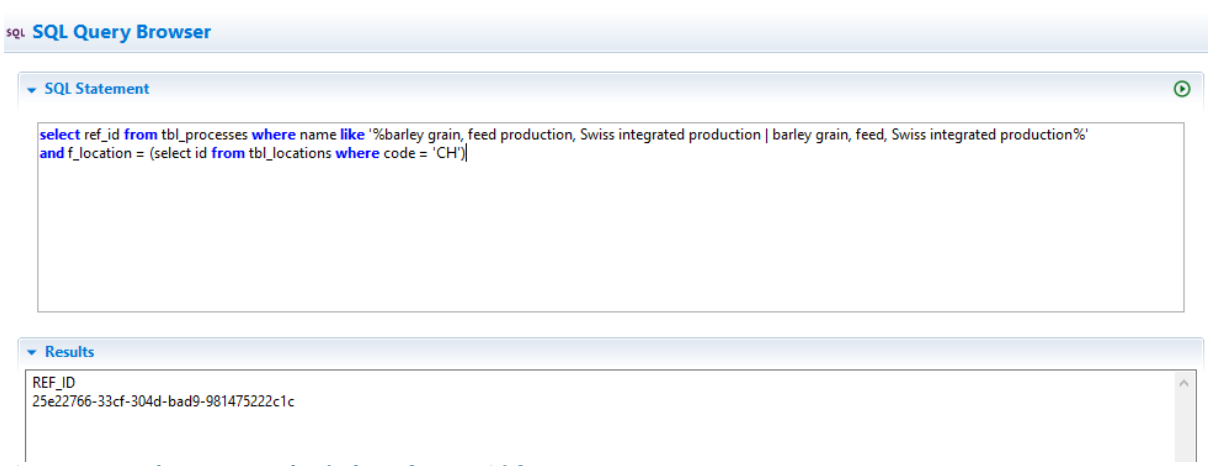

Figure 9: Run the query to check the reference id for a process

If the compatibility check turns out negative, please contact GreenDelta GmbH.

4.2 Export and import between different versions of ecoinvent

Before migrating data from a previous version of ecoinvent into ecoinvent 3.8, perform a compatibility check and create backup of your databases to ensure that original data is retrievable.

It should be noted that there is an exception. Some processes in previous versions of ecoinvent are not present in version 3.8 anymore, as they were either deleted, disaggregated or replaced by several more specific processes, or merged together with some other processes. In such cases, the different UUIDs were kept, and providers have to be selected manually after importing the foreground system. Please note that in case, the geography of the process or the REF_ID of the product was modified comparing ecoinvent 3.7.1 and 3.8, then no process will be selected also. For organisational reasons, the REF_IDs of some processes were modified, and, therefore, for these specific cases, the provider should also be manually selected.

4.2.1 Export

Open the ecoinvent database from which you want to export data by double-clicking on it. Choose the *JSON-LD* export wizard in the folder openLCA and click *Next*. Select the data sets which you would like to export (Figure 10). **Make sure that you do not accidentally select all processes in your database as this will prolong the export (and subsequently the import) extremely.** Select a file path for saving the JSON-LD file and click *Finish*.

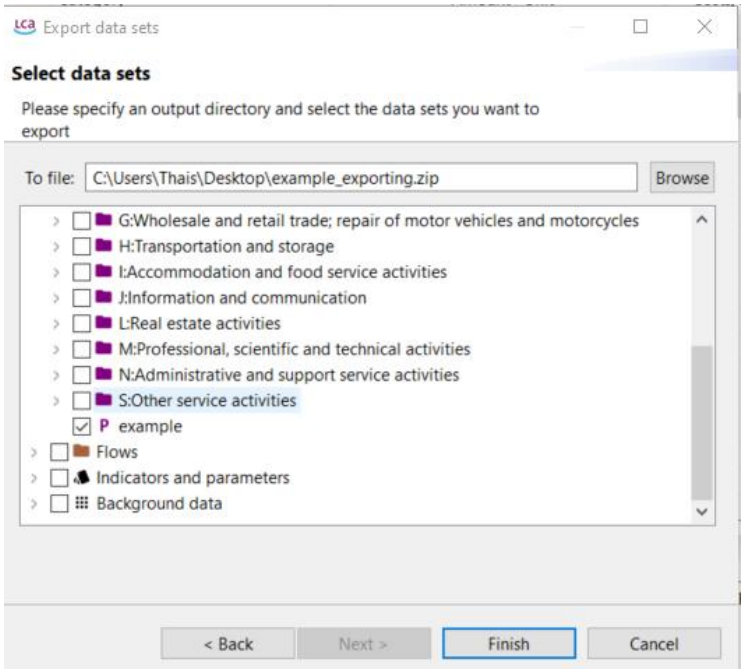

Figure 10: Export window in openLCA

4.2.2 Import

Similarly, 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 11). 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 12).

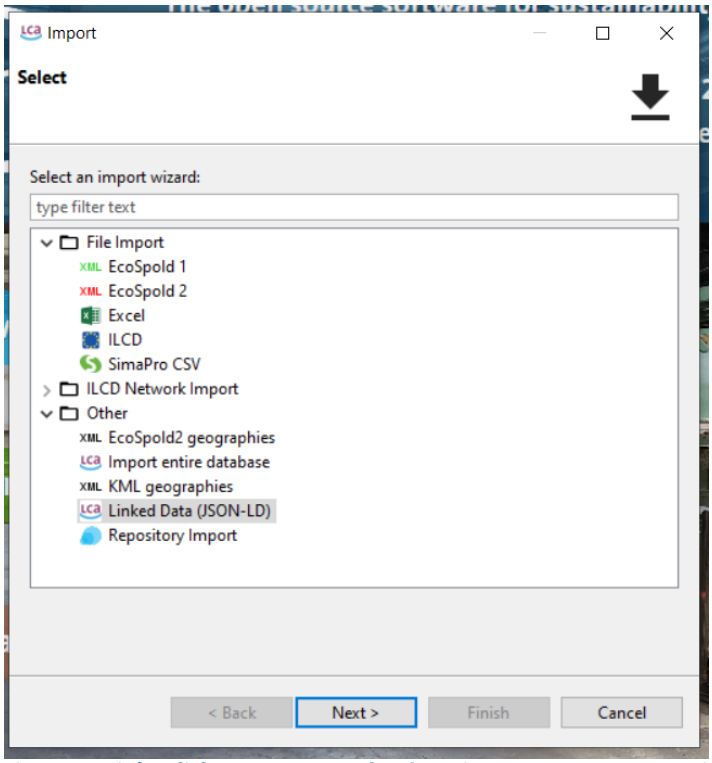

Figure 11: Right-click onto an open database in openLCA to open an import wizard

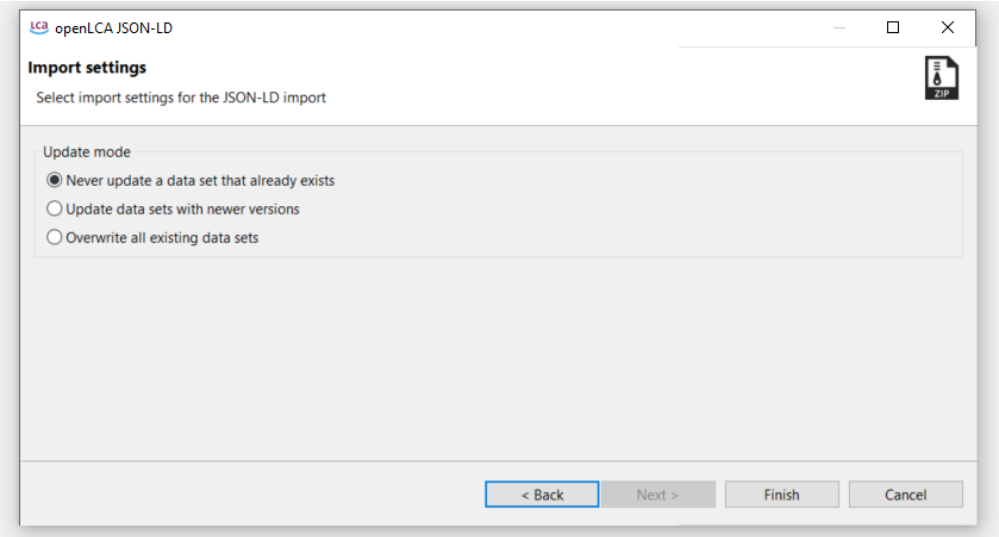

Figure 12: Select Never update a data set that already exists in the import settings

After importing, the providers of the flows will be automatically connected in case the equivalent process is available in the database.

5 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.3.8 database in openLCA, please contact us.