# Documentation of changes implemented in the ecoinvent database v3.8 (2021.09.21)

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# 1 Introduction: highlight of the changes in the database v3.8

Users migrating from the v3.7.1 (released 2020) to the v3.8 (released 2021) of the ecoinvent database are going to find some differences in the content and the scores obtained with the database. This report is describing at length the changes in content or modelling experienced by individual datasets in the database, as well as improvements and updates to the documentation or usability of the data.

## 1.1 New Features

The v3.8 has a strong focus on improving the user experience when working with the ecoinvent database. In that regard, different features have been added:

- Product information: products and services included in the database now integrate a description that supports users in identifying them. The product information for products entails a definition of the product from the database standpoint while for service provision (additionally), assistance is provided on how those services shall be used.

- Market information: with the objective of making the use and function of the markets clearer for the users, all markets have been reviewed and their existing meta information complemented, corrected, or completed.

- Database Overview: to provide are more concise overview of the contents of the ecoinvent database, the information has been centralized into one file; "Database Overview for ecoinvent 3.8". It contains the following information:

    - The list of datasets contained in the Undefined database and each of the system models. For version 3.8, each dataset has been assigned to one or more sectors, which help filter for datasets that can belong to different sectors.

    - The geographies used in the ecoinvent database. Each geography is assigned a classification, and the geographies that are contained in each geography are indicated.

    - The list of the LCIA methods for which ecoinvent calculates impact scores. The version of the methods is indicated, and the original source used for defining the characterization factors is provided.

## 1.2 New system model for EPD practitioners

Acknowledging the increasing importance of Environmental Product Declarations (EPDs) in the construction and manufacturing sector and the need for standardized, accurate, non-misleading communication of the environmental information for products, the ecoinvent association introduced the ‘allocation, cut-off, EN15804’ system model. The aim of this system model is twofold; on the one hand, the ‘allocation, cut-off, EN15804’ facilitates the EPD practitioners to comply with the standard EN15804&A2:2019. On the other hand, the new system model contributes to a harmonization 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.

More information on the new system model and on the assumptions behind the calculation of the new properties and indicators can be found in Ioannidou et al., 2021.

### 1.3 Better support for GHG Protocol

With the updates of ecoinvent 3.8, the ecoinvent database offers the possibility to calculate emissions from electricity according to Scope 2 and Scope 3 Guidance of the GHG Protocol. Separated scope 2 and 3 emission factors (given as kg of CO2 equivalent/kWh of electricity) for electricity producing activities and electricity markets are now available in a spreadsheet ("electricity emission factors – scope 2 – 3.xlsx"). Emission factors are calculated based on the GWP100 (global warming potential) values from the IPCC 2013 AR5 report. They are representative for the end consumers of electricity and refer to the location-based reporting method, i.e., they represent grid average emission factors. On top of this, the new spreadsheet also provides disaggregated emission (given as kg /kWh of electricity) and emission factors (given as kg of CO2 equivalent/kWh of electricity) for individual greenhouse gases or groups of greenhouse gases.

The spreadsheet "electricity emission factors – scope 2 – 3.xlsx" can be found in the files section of ecoQuery v3.8. More information on underlying assumptions of the calculation is explained in more detail in Bourgault G. and Minas, M. (2021), available in the report section of ecoQuery v3.8.

### 1.4 New data

The v3.8 also adds and correct content of the v3.7.1; those are the highlights:

- Brazilian data: the Cornerstone project was set up between Rede ACV (the Brazilian business network for LCA) and the ecoinvent association to improve the availability and access to background data on key supply chain for Brazil. Rede ACV, through its contractor ACV Brasil, departed from existing content in the ecoinvent database to develop regionalized life cycle inventory (LCI) data representative of the situation in Brazil. The data in v3.8 covers the extraction, import and distribution of crude petroleum oil and natural gas, production of biodiesel (esterification of fatty acid methyl ester, FAME), distribution of diesel (for transport), and road freight transport by lorry. Older ecoinvent datasets have been updated for v3.8 to better reflect the country-specific supply of crude petroleum oil to petroleum refinery operation in Brazil.

- Agriculture: the sector features a small update with the representation of new products, such as lentils and peas, and the recontextualization of agricultural services for Canada. Data for these updates were provided by the University of British Columbia and the Food Systems PRISM Laboratory.

- Batteries: ecoinvent v3.8 includes new datasets for three types of Li-Ion batteries (NCA, NMC111, NMC811) and their production. These datasets were created by the Swiss Federal Laboratories for Materials Science and Technology (EMPA) and incorporate various chemicals, such as cobalt sulphate, disodium disulphite, vinyl carbonate and oxides, and hydroxides for the three battery types. The individual battery components (cathode, anode, high and low voltage systems, cells and battery management systems) are split, and each is represented in an individual dataset. Complementary, a new dataset on lead-acid batteries created by the University of Pforzheim is also included in the v3.8 update.

- Chemicals & Plastics: in ecoinvent v3.8, we continued our efforts to update data and strengthen the collaboration with the industry. Data for styrene production was updated with the support of PlasticsEurope and new and updated data for polyurethane foam was provided by EUROPUR.

- Electricity: ecoinvent v3.8 contains updated, attributional electricity markets for most countries with a reference year of 2018. In the case of US and Canada, the reference year is 2019. Additionally, the Swiss electricity markets as well as transformation losses (high to medium and

medium to low voltage) for all updated markets were adjusted. Data creation and review was done in collaboration with ETH Zurich and the Paul Scherrer Institute (PSI).

- Electronics: the v3.8 includes new datasets on consumer electronic devices. Based on the latest literature data, datasets for smartphone and tablet were added and the existing dataset for laptop was updated. For the mobile devices a new printed wiring board and liquid crystal display dataset were created. Components in the corresponding supply chain have been adjusted as needed.

- Forestry and wood-based products: the wood sector has been updated with new data for bamboo forestry and the production of (intermediate) bamboo construction materials. i.e., bamboo pole, flattened bamboo, and woven bamboo mat. These new datasets were developed with the support of ETH and the International Organization for Bamboo and Rattan INBAR.

- Metals: new and updated datasets for the metals sector have been provided by EMPA (sponsored by the Swiss Federal Office for the Environment, BAFU) for ecoinvent version 3.8. The new data cover the production beryllium, ferroniobium and scandium oxide produced from rare earth tailings. Updates were provided by EMPA for the production of ferrochromium, lithium carbonate, strontium sulfate, tantalum, titanium, as well as for the mining of heavy mineral sands. Additionally, changes have been made to the datasets modelling the smelting of copper concentrate in order to make certain values region-specific.

- Transport: in collaboration with INFRAS, the datasets for air freight (belly and dedicated) transport are updated. The consumption of kerosene and the corresponding emissions were too low (version 3.6 to 3.7.1).

- Resource correction for biogenic carbon. In the “allocation, cut-off by classification” system model, the data for the forestry, wood, paper and cardboard sectors, biogenic carbon balances are restored after allocation using a new elementary exchange that allows to follow the process transparently.

For a full comparison, at the exchange level, between the versions of the database, the Change Report Annex can be downloaded as an excel file from the “Files” section of the ecoQuery by license holders only. This file lists all activities highlighting its changes, it also aligns the 2 versions of the activities, at the flow level, to allow change tracking.

Correspondence files for each system model, as well as for the Undefined database are provided together with this report; they can be checked for equivalences in case of deletion or disaggregation of activities.

More information about the technical background of the sectors can be found in the dedicated sectorial pages, on the ecoinvent website.

### 1.5 Consequences in results of the data updates

273 indicators have been analysed, covering the categories: acidification; climate change; eutrophication; ecotoxicity; human toxicity; ionising radiation; land use; malodours air; photochemical oxidant formation; energy resources / material resources; ozone depletion; energy resources: non-renewable; material resources: metals/minerals; energy resources: renewable; water use; acidification / eutrophication; particulate matter formation; waste disposal; energy resources; material resources; material resources: wood.

The methods used for the comparison were those present in both v3.7.1 and v3.8 versions: CML 2001 ; cumulative energy demand; eco-indicator 99, (E,E) ; eco-indicator 99, (H,A) ; eco-indicator 99, (I,I) ; ecological footprint; ecological scarcity 2013; ecosystem damage potential; EDIP2003; EF v2.0 2018; EPS 2000; IMPACT 2002+ (Endpoint); IPCC 2013; ReCiPe Midpoint (E) V1.13; ReCiPe Midpoint (H) V1.13; ReCiPe Midpoint (I) V1.13; TRACI; USEtox. The full list of indicators can be found in Annex 1: Indicators.

A full comparison can be downloaded from the “Files” section of ecoQuery, together with the Change Report Annex.

Most score changes experienced in the database in the cut-off system model, for all indicators, are under 10% increase or decrease in scores, as can be seen in Figure 1. Smaller parts of the database experience bigger changes in scores (metal depletion, global warming potential, acidification, ecotoxicity, human toxicity). Several corrections or additions are behind those changes, with some indicators being more sensitive than others.

The metals update (strontium, lithium, rare earths, titanium and copper, with different influence depending on the indicator) induce justified changes from 10% up to 70% in the score comparison between v3.7.1 and v3.8, to around 50% of the data in the database with some indicators (metal depletion and ecotoxicity mainly).

Characterization factors for the EF2.0 method were updated or added to some elementary exchanges; this is behind larger changes in scores between v3.7.1 and v3.8; specially under the indicator carcinogenic substances. Around 50% of the datasets in the database experience changes in scores up to 50% value. Read more in chapter 2.5.3.

The corrections in air transport affect largely results though to a limited number of datasets (see chapter 13.1). The corrections in the chemicals (corrections in the supply chain of “ethoxylated alcohol (AE3), petrochemical”, or on the styrene production and chichibabin amination), on the other hand, have large influences in some categories (ecotoxicity, acidification, human toxicity, global warming potential), though affecting discrete parts of the database (read more about the changes in chapter 8). The update in the electronics sector, mainly the components update (ie. router, resistor) drives large differences in almost all indicators, but very restricted to the electronics sector itself.

The Brazilian supply chains show big differences in categories such as agricultural land occupation and marine eutrophication (increases of 90% of previous scores, when the new Brazilian and the old global data are compared). These differences can be traced back to the production of soybeans and the extensive use of soybean oil in the average feedstock mix for the esterification of vegetable oils and animal fats in Brazil, and are visible in markets now using the supply of Brazilian transport. For more information, see chapter 4.1.

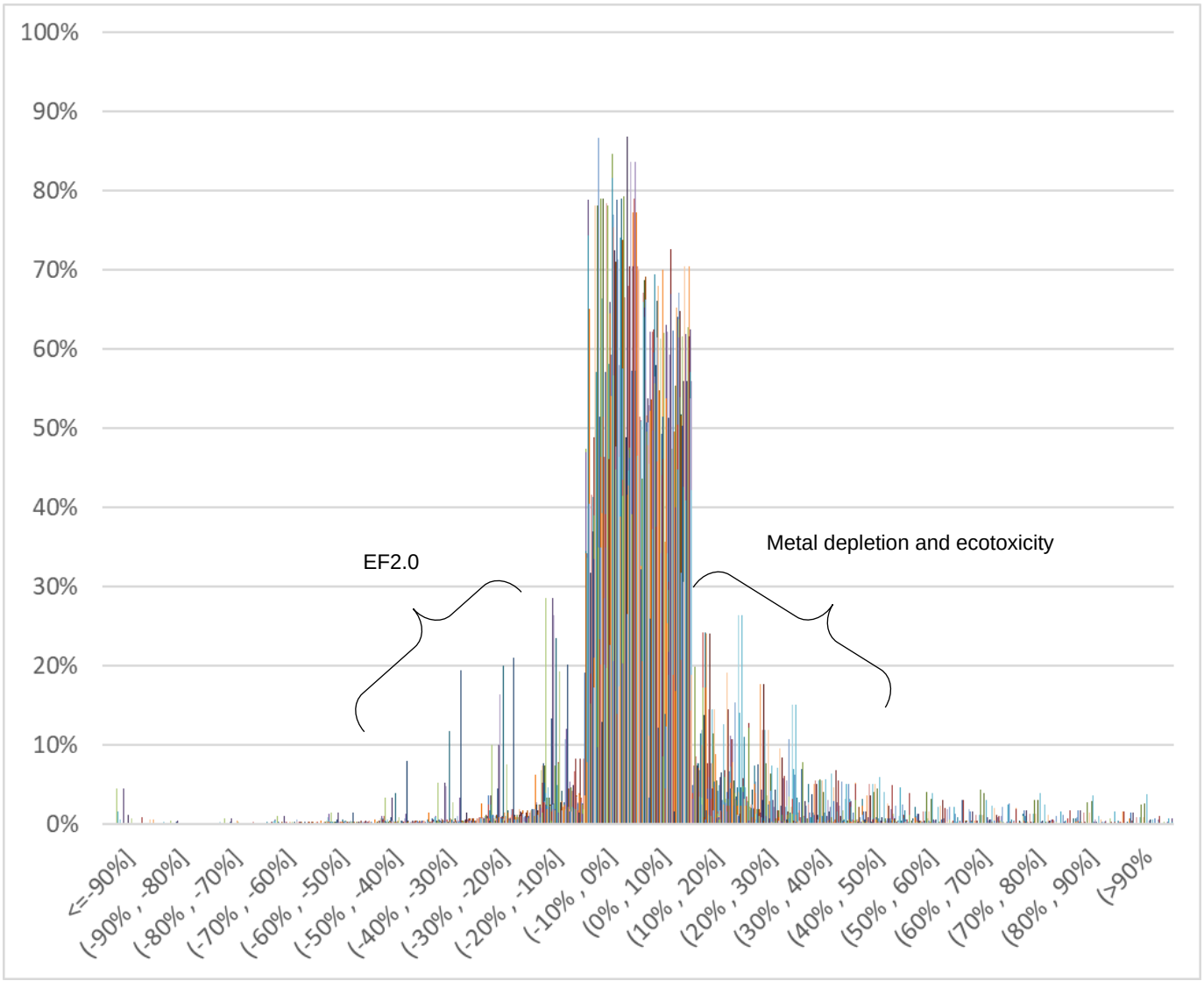


***Figure 1. Comparison of results in the "Allocation, cut-off by classification" system model between v3.7.1 and v3.8.*** *The indicators compared are listed in the text. The vertical axis represents the proportion of the database affected by the change in score, represented in the horizontal axis as intervals.*

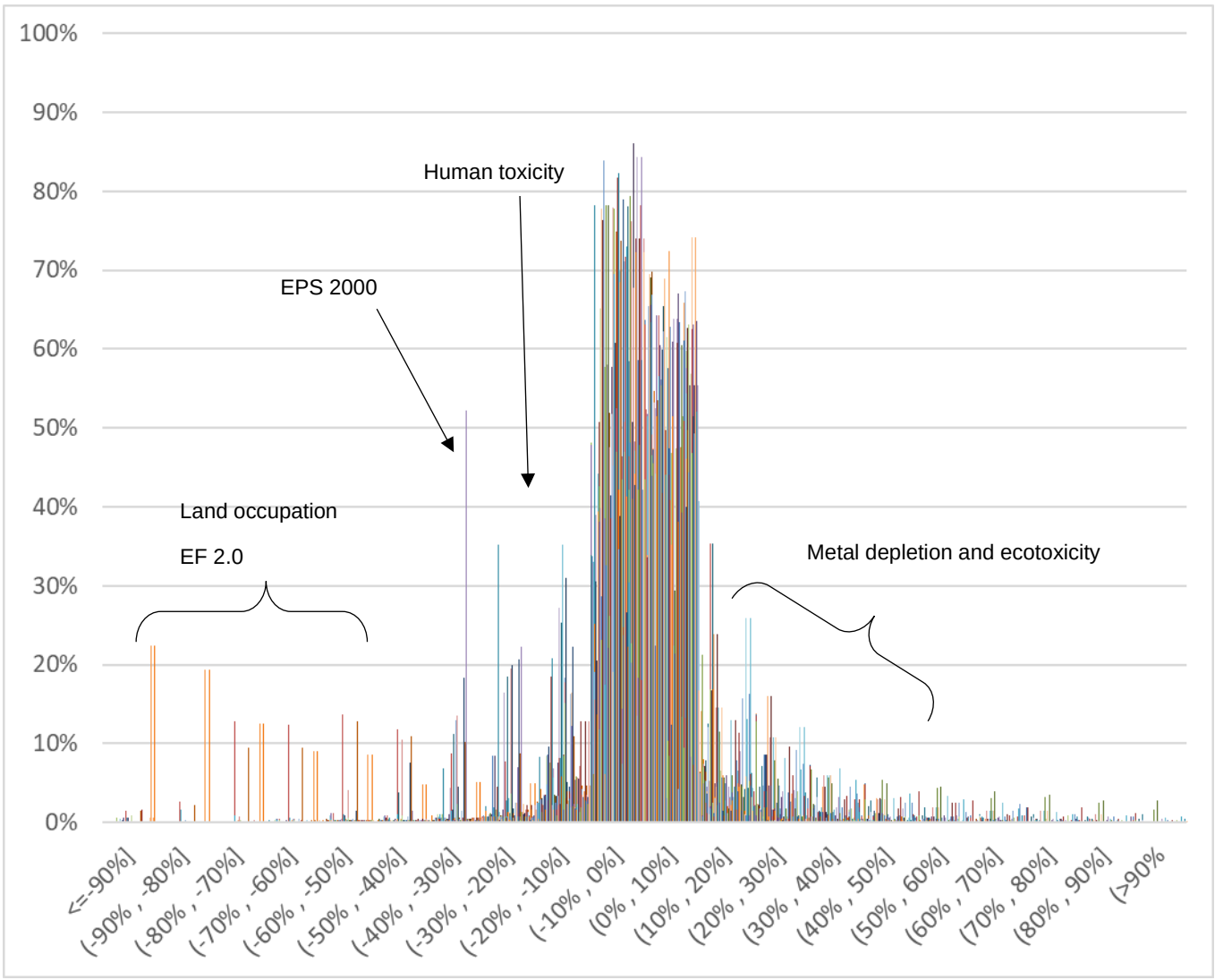


***Figure 2. Comparison of results in the "Allocation, APOS" system model between v3.7.1 and v3.8.*** *The indicators compared are listed in the text. The vertical axis represents the proportion of the database affected by the change in score, represented in the horizontal axis as intervals.*

The APOS system model shows a similar behaviour and reflect the changes in a similar way (Figure 2), though some indicators are more sensitive and relevant to capture changes in this system model. For example, results obtained with the EPS 2000 method (total emissions into soil) stand out, showing a reduction of up to 50% relative scores when comparing v3.7.1 and v3.8 for more than 50% of the database. Otherwise, results obtained with urban land occupation or land occupation indicators show large score changes for up to 20% of the database (depending on the indicator).

The updates causing the changes in score are the same as analysed in the paragraphs above, ultimately the end-of-life of by-products causing the differences to be larger for some indicators in APOS than in cut-off.

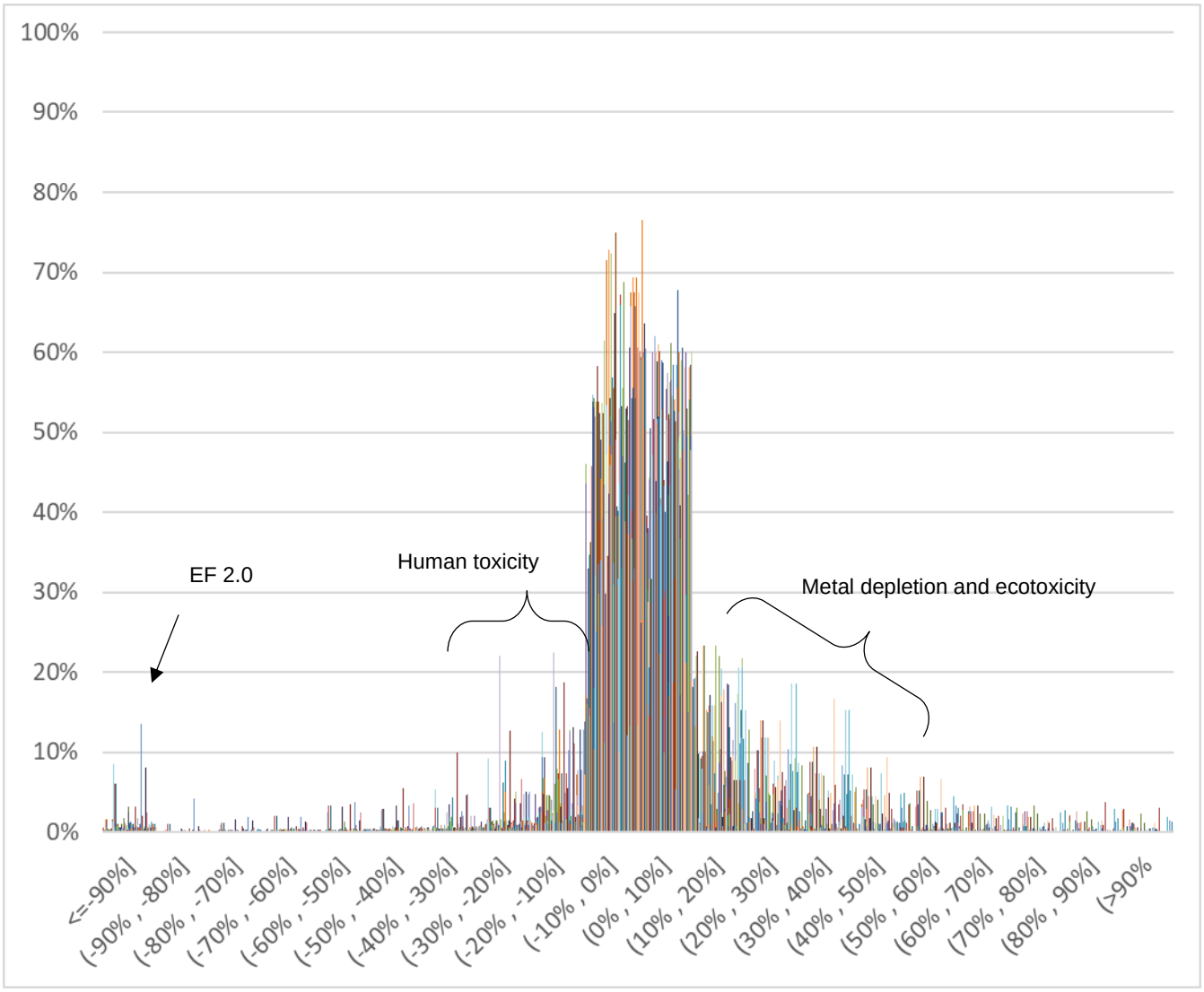


***Figure 3. Comparison of results in the "Consequential, substitution, long-term" system model between v3.7.1 and v3.8.*** *The indicators compared are listed in the text. The vertical axis represents the proportion of the database affected by the change in score, represented in the horizontal axis as intervals.*

The consequential system model shows a very similar score behaviour when comparing v3.7.1 and v3.8 (Figure 3). In this case, explained by the fact that by-products do not get allocated but instead give credits to the producing activities, the changes are more distributed. Most of the indicators concentrate the changes (more than 70% of the database) around 10% increase or decrease of scores when comparing the two versions. There is, however, two additional bigger clusters of changes: from 10% to 50% relative increase and from 10% to 20% relative decrease.

# 2 Database-wide changes

## 2.1 Renamed activities and exchanges

Some activities or products were renamed for version 3.8. The changes are listed in the following tables, and in the sector-dedicated chapters if associated to it there was a change in the modelling.

***Table 1. Activities renamed for v3.8.*** *Most of the changes aim at better defining the scope of the activity. More details of some changes are given in the corresponding chapters.*

| Activity Name v3.7.1 | Activity Name v3.8 |
|---|---|
| compact fluorescent lamp | compact fluorescent lamp production |
| concrete slab | concrete slab production |
| electricity production, hydro, reservoir, alpine region, label-certified | electricity production, hydro, reservoir, alpine region, renewable energy products |
| electricity production, hydro, run-of-river, label-certified | electricity production, hydro, run-of-river, renewable energy products |
| electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted, label-certified | electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted, renewable energy product |
| electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted, label-certified | electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted, renewable energy produc |
| electricity production, wind, <1MW turbine, onshore, label-certified | electricity production, wind, <1MW turbine, onshore, renewable energy products |
| electricity production, wind, >3MW turbine, onshore, label-certified | electricity production, wind, >3MW turbine, onshore, renewable energy products |
| electricity production, wind, 1-3MW turbine, onshore, label-certified | electricity production, wind, 1-3MW turbine, onshore, renewable energy products |
| electricity voltage transformation from high to medium voltage, label-certified | electricity voltage transformation from high to medium voltage, renewable energy products |
| electricity voltage transformation from medium to low voltage, label-certified | electricity voltage transformation from medium to low voltage, renewable energy products |
| energy use and operation emissions, electric bicycle, label-certified electricity | energy use and operation emissions, electric bicycle, electricity from renewable energy products |
| ferrochromium production, high carbon, 55% Cr | ferrochromium production, high-carbon, 55% Cr |
| fertilising, by stool spliter, sugarcane | fertilising, by stool splitter, sugarcane |
| foam glass production, electricity, label-certified | foam glass production, electricity from renewable energy products |
| foam glass production, without cullet, electricity, label-certified | foam glass production, without cullet, electricity from renewable energy products |
| heat and power co-generation, biogas, gas engine, label-certified | heat and power co-generation, biogas, gas engine, renewable energy products |
| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014, label-certified | heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014, renewable energy products |
| heat pump production, for heat and power co-generation unit, 160kW electrical | heat pump production, heat and power co-generation unit, 160kW electrical |
| housing system construction, pig, label-certified | housing system construction, pig, electricity from renewable energy products |
| leaching of spodumene with sulfuric acid | lithium carbonate production, from spodumene |
| market for cement, limestone cement 6-20% | market for cement, limestone 6-20% |
| market for chemicals, inorganic | market for chemical, inorganic |
| market for copper smeting facility | market for copper smelting facility |
| market for electricity, high voltage, label-certified | market for electricity, high voltage, renewable energy products |
| market for electricity, low voltage, label-certified | market for electricity, low voltage, renewable energy products |
| market for electricity, medium voltage, label-certified | market for electricity, medium voltage, renewable energy products |
| market for energy use and operation emissions, electric bicycle, label-certified electricity | market for energy use and operation emissions, electric bicycle, electricity from renewable energy products |
| market for ethylene, average | market for ethylene |

| Activity Name v3.7.1 | Activity Name v3.8 |
|---|---|
| market for vegetable oil methyl ester | market for fatty acid methyl ester |
| market for ferrochromium, high carbon, 55% Cr | market for ferrochromium, high-carbon, 55% Cr |
| market for fish oil | market for fish oil, from anchovy |
| market for foam glass, electricity, label-certified | market for foam glass, electricity from renewable energy products |
| market for furniture | market for furniture, wooden |
| market for heat and power co-generation unit construction, 6400kW thermal, building | market for heat and power co-generation unit, 6400kW thermal, building |
| market for heat and power co-generation unit construction, 6400kW thermal, common components for heat+electricity | market for heat and power co-generation unit, 6400kW thermal, common components for heat+electricity |
| market for heat and power co-generation unit construction, 6400kW thermal, components for electricity only | market for heat and power co-generation unit, 6400kW thermal, components for electricity only |
| market for housing system, pig, label-certified, per pig place | market for housing system, pig, per pig place, electricity from renewable energy products |
| market for laterite | market for laterite, mineral |
| market for microwave oven production | market for microwave oven |
| market for nuclear power plant, pressure water reactor 1000MW | market for nuclear power plant, pressure water reactor, 1000MW |
| market for nuclear power plant, pressure water reactor 650MW | market for nuclear power plant, pressure water reactor, 650MW |
| market for operation, computer, laptop, 68% active work with internet access 0.2 Mbit/s, label-certified electricity | market for operation, computer, laptop, 68% active work with internet access 0.2 Mbit/s, electricity from renewable ener |
| market for operation, computer, laptop, 68% active work, label-certified electricity | market for operation, computer, laptop, 68% active work, electricity from renewable energy products |
| market for operation, computer, laptop, video mode, label-certified electricity | market for operation, computer, laptop, video mode, electricity from renewable energy products |
| market for operation, computer, laptop, videoconference, label-certified electricity | market for operation, computer, laptop, videoconference, electricity from renewable energy products |
| market for operation, housing system, pig, label-certified, per pig place | market for operation, housing system, pig, per pig place, electricity from renewable energy products |
| market for operation, internet access equipment, label-certified electricity | market for operation, internet access equipment, electricity from renewable energy products |
| market for permanent magnet, electric passenger car motor | market for permanent magnet, for electric motor |
| market for refinery | market for petroleum refinery |
| market for phosphoryl chloride | market for phosphorus oxychloride |
| market for ventilation duct, PE corrugated tube, DN 75 | market for polyethylene pipe, corrugated, DN 75 |
| market for earth tube heat exchanger, polyethylene, DN 200 | market for polyethylene pipe, DN 200, SDR 41 |
| market for electric powertrain, for electric scooter | market for powertrain, for electric scooter |
| market for sawnwood, azobe, dried (u=20%), planed | market for sawnwood, azobe, dried (u=15%), planed |
| market for spent oxychlor catalyst for ethylene dichloride production | market for spent oxychlor catalyst |
| market for strontium sulfate, unprocessed | market for strontium sulfate, 90% SrSO4 |
| market for sulfidic tailing, off-site, high-gold content | market for sulfidic tailing, off-site, high gold content |
| market for tantalum, powder, capacitor-grade | market for tantalum powder, capacitor-grade |
| market for textile, non woven polyester | market for textile, nonwoven polyester |
| market for textile, non woven polypropylene | market for textile, nonwoven polypropylene |
| market for tillage, harrowing, by offset disk harrow | market for tillage, harrowing, by offset disc harrow |
| market for titanium, primary | market for titanium |
| market for titanium primary, triple-melt | market for titanium, triple-melt |
| market for transport, freight, lorry 28 metric ton, vegetable oil methyl ester 100% | market for transport, freight, lorry 28 metric ton, fatty acid methyl ester 100% |
| market for transport, passengers, aircraft, long haul | market for transport, passenger aircraft, long haul |
| market for transport, passengers, aircraft, medium haul | market for transport, passenger aircraft, medium haul |
| market for transport, passengers, aircraft, short haul | market for transport, passenger aircraft, short haul |
| market for transport, passenger, aircraft, unspecified | market for transport, passenger aircraft, unspecified |
| market for transport, passengers, aircraft, very short haul | market for transport, passenger aircraft, very short haul |
| market for transport, passenger car, large size, petol, EURO 4 | market for transport, passenger car, large size, petrol, EURO 4 |

| Activity Name v3.7.1 | Activity Name v3.8 |
|---|---|
| market for transport, passenger, electric bicycle, label-certified electricity | market for transport, passenger, electric bicycle, electricity from renewable energy products |
| market for tree seedling | market for tree seedling, for planting |
| market for used glider from electric scooter | market for used glider, electric scooter |
| market for used industrial electronic device, WEEE collection | market for used industrial electronic device |
| market for used powertrain from electric scooter | market for used powertrain, electric scooter |
| market for venting, from carbon dioxide in chemical industry | market for venting of carbon dioxide, in chemical industry |
| market for waste mineral wool, final disposal | market for waste mineral wool, for final disposal |
| market for waste plastic plaster, final disposal | market for waste plastic plaster, for final disposal |
| market for network connection, turbine 2MW, onshore | market for wind turbine network connection, 2MW, onshore |
| market for network connection, turbine 4.5MW, onshore | market for wind turbine network connection, 4.5MW, onshore |
| market for wood pellet | market for wood pellet, measured as dry mass |
| market for wood preservation, vaccum pressure method, inorganic salt, containing Cr, outdoor use, ground contact | market for wood preservation, vacuum pressure method, inorganic salt, containing Cr, outdoor use, ground contact |
| market group for transport, freight, lorry 28 metric ton, vegetable oil methyl ester 100% | market group for transport, freight, lorry 28 metric ton, fatty acid methyl ester 100% |
| medium density fibre board production, uncoated | medium density fibreboard production, uncoated |
| butane extraction, from natural gas liquids | natural gas liquids fractionation |
| ethane extraction, from natural gas liquids | |
| pentane extraction, from natural gas liquids | |
| propane extraction, from liquefied petroleum gas | |
| nuclear power plant construction, pressure water reactor 1000MW | nuclear power plant construction, pressure water reactor, 1000MW |
| operation, computer, laptop, 68% active work with internet access 0.2 Mbit/s, label-certified electricity | operation, computer, laptop, 68% active work with internet access 0.2 Mbit/s, electricity from renewable energy products |
| operation, computer, laptop, 68% active work, label-certified electricity | operation, computer, laptop, 68% active work, electricity from renewable energy products |
| operation, computer, laptop, video mode, label-certified electricity | operation, computer, laptop, video mode, electricity from renewable energy products |
| operation, computer, laptop, videoconference, label-certified electricity | operation, computer, laptop, videoconference, electricity from renewable energy products |
| operation, housing system, pig, label-certified | operation, housing system, pig, electricity from renewable energy products |
| operation, internet access equipment, label-certified electricity | operation, internet access equipment, electricity from renewable energy products |
| phosphorus oxychloride production | phosphorus oxychloride production, from phosphorus pentachloride |
| phosphoryl chloride production | phosphorus oxychloride production, from phosphorus trichloride |
| polyurethane production, flexible foam | polyurethane production, flexible foam, MDI-based |
| polyurethane production, flexible foam | polyurethane production, flexible foam, TDI-based, high density |
| polyurethane production, flexible foam | polyurethane production, flexible foam, TDI-based, low density |
| stirling heat and power co-generation unit construction, 3kW electrical, future | stirling heat and power co-generation unit construction, 3kW electrical, wood pellet, future |
| strontium sulfate quarry operation | strontium mine operation and beneficiation |
| tantalum production, powder, capacitor-grade | tantalum powder production, capacitor-grade |
| textile production, non woven polyester, needle punched | textile production, nonwoven polyester, needle-punched |
| textile production, non woven polypropylene, spun bond | textile production, nonwoven polypropylene, spunbond |
| tillage, harrowing, by offset disk harrow | tillage, harrowing, by offset disc harrow |
| titanium production, primary | titanium production |
| titanium production, primary, triple melt | titanium production, triple-melt |
| transport, freight, lorry 28 metric ton, vegetable oil methyl ester 100% | transport, freight, lorry 28 metric ton, fatty acid methyl ester 100% |
| transport, passenger, aircraft, all distances to generic market for transport, passenger, unspecified | transport, passenger aircraft, all distances to generic market for transport, passenger aircraft, unspecified |
| transport, passengers, passenger aircraft, long haul | transport, passenger aircraft, long haul |
| transport, passengers, passenger aircraft, medium haul | transport, passenger aircraft, medium haul |

| Activity Name v3.7.1 | Activity Name v3.8 |
|---|---|
| transport, passengers, passenger aircraft, short haul | transport, passenger aircraft, short haul |
| transport, passengers, passenger aircraft, very short haul | transport, passenger aircraft, very short haul |
| transport, passenger, electric bicycle, label-certified electricity | transport, passenger, electric bicycle, electricity from renewable energy products |
| treatment of used internal combustion engine, shredding | treatment of used internal combustion engine, passenger car, shredding |
| treatment of used powertrain for electric scooter, manual dismantling | treatment of used powertrain, electric scooter, manual dismantling |

***Table 2. Intermediate exchanges renamed for version 3.8.*** *Most of the changes aim at improving the product name, increasing precision. More details of some changes are given in the corresponding chapters.*

| Product Name v3.7.1 | Product Name v3.8 |
|---|---|
| assembly of generator and motor, auxilliaries and energy use, for heat and power co-generation unit, 160 KW electrical | assembly of generator and motor, auxilliaries and energy use, heat and power co-generation unit, 160kW electrical |
| cement, blast furnace 40-70% | cement, blast furnace slag 40-70% |
| cement, blast furnace slag, 66-80% | cement, blast furnace slag 66-80% |
| compact fluorescent bulb | compact fluorescent lamp |
| copper smeting facility | copper smelting facility |
| electricity, high voltage, label-certified | electricity, high voltage, renewable energy products |
| electricity, low voltage, label-certified | electricity, low voltage, renewable energy products |
| electricity, medium voltage, label-certified | electricity, medium voltage, renewable energy products |
| energy use and operation emissions, electric bicycle, label-certified electricity | energy use and operation emissions, electric bicycle, electricity from renewable energy products |
| ethanol, without water, in 99.7% solution state, vehicle grade | ethanol, without water, in 99.7% solution state, from fermentation, vehicle grade |
| ethylene, average | ethylene |
| vegetable oil methyl ester | fatty acid methyl ester |
| ferrochromium, high carbon, 55% Cr | ferrochromium, high-carbon, 55% Cr |
| fibre-reinforced concrete | fibre-reinforced concrete, steel |
| foam glass, electricity, label-certified | foam glass, electricity from renewable energy products |
| glued laminated timber, for indoor use | glued laminated timber, average glue mix |
| heat pump, for heat and power co-generation unit, 160kW electrical | heat pump, heat and power co-generation unit, 160kW electrical |
| heat, borehole heat pump | heat, brine-water heat pump 10kW |
| housing system, pig, label-certified, per pig place | housing system, pig, per pig place, electricity from renewable energy products |
| internal combustion engine, for passenger car | internal combustion engine, passenger car |
| fish, marine | marine fish |
| nuclear power plant, pressure water reactor 1000MW | nuclear power plant, pressure water reactor, 1000MW |
| operation, computer, laptop, 68% active work with internet access 0.2 Mbit/s, label-certified electricity | operation, computer, laptop, 68% active work with internet access 0.2 Mbit/s, electricity from renewable energy products |
| operation, computer, laptop, 68% active work, label-certified electricity | operation, computer, laptop, 68% active work, electricity from renewable energy products |
| operation, computer, laptop, video mode, label-certified electricity | operation, computer, laptop, video mode, electricity from renewable energy products |
| operation, computer, laptop, videoconference, label-certified electricity | operation, computer, laptop, videoconference, electricity from renewable energy products |
| operation, housing system, pig, label-certified, per pig place | operation, housing system, pig, per pig place, electricity from renewable energy products |
| operation, internet access equipment, label-certified electricity | operation, internet access equipment, electricity from renewable energy products |

| Product Name v3.7.1 | Product Name v3.8 |
|---|---|
| phosphoryl chloride | phosphorus oxychloride |
| photovoltaic plant, electric installation for 3kWp module | photovoltaics, electric installation for 3kWp module, at building |
| photovoltaic plant, electric installation for 570kWp open ground module | photovoltaics, electric installation for 570kWp module, open ground |
| sawnwood, azobe, dried (u=20%), planed | sawnwood, azobe, dried (u=15%), planed |
| stirling heat and power co-generation unit, 3kW electrical, future | stirling heat and power co-generation unit, 3kW electrical, wood pellet, future |
| strontium sulfate, unprocessed | strontium sulfate, 90% SrSO4 |
| tantalum, powder, capacitor-grade | tantalum powder, capacitor-grade |
| textile, non-woven polyester | textile, nonwoven polyester |
| textile, non-woven polypropylene | textile, nonwoven polypropylene |
| tillage, harrowing, by offset disk harrow | tillage, harrowing, by offset disc harrow |
| titanium, primary | titanium |
| titanium primary, triple-melt | titanium, triple-melt |
| transport, freight, lorry 28 metric ton, vegetable oil methyl ester 100% | transport, freight, lorry 28 metric ton, fatty acid methyl ester 100% |
| transport, passengers, aircraft, long haul | transport, passenger aircraft, long haul |
| transport, passengers, aircraft, medium haul | transport, passenger aircraft, medium haul |
| transport, passengers, aircraft, short haul | transport, passenger aircraft, short haul |
| transport, passenger, aircraft, unspecified | transport, passenger aircraft, unspecified |
| transport, passengers, aircraft, very short haul | transport, passenger aircraft, very short haul |
| transport, passenger, electric bicycle, label-certified electricity | transport, passenger, electric bicycle, electricity from renewable energy products |
| used glider, from electric scooter | used glider, electric scooter |
| used internal combustion engine, from passenger car | used internal combustion engine, passenger car |
| used powertrain, from electric scooter | used powertrain, electric scooter |
| venting, from carbon dioxide in chemical industry | venting of carbon dioxide, in chemical industry |
| wood preservation, vaccum pressure method, inorganic salt, containing Cr, outdoor use, ground contact | wood preservation, vacuum pressure method, inorganic salt, containing Cr, outdoor use, ground contact |

## 2.2 Changes affecting attributional system models

Changes in price affect the results obtained with the attributional system models, when economic allocation is used. Several prices of products have been adjusted (sometimes only minorly) for the v3.8. The full list of products that experimented a price change can be found in Annex 2: Products with updated prices.

## 2.3 Lower Heating Value for all products

In v3.8, the property of Lower Heating Value has been added to all relevant products in the database, namely all intermediate exchanges that represent combustible products. The unit of this new property is MJ per functional unit of product (e.g. MJ/kg, MJ/$m^3$ etc). More specifically, a new LHV has been added to 862 products. When products already had a LHV, this value was maintained, provided that it was expressed in MJ per unit of product. In 20 products where this was not the case, or where an erroneous value for LHV was assigned until now, this value has now been corrected. The above procedure resulted in a harmonization of all LHV properties in the database. More information on the methodology followed for assigning the proper LHVs to all products can be found in the "allocation, cut-off, EN15804 system model" documentation (Ioannidou et al., 2021).

### 2.3.1 Modifications of heat production datasets

As a result of the creation of new LHVs and the correction of others, the natural gas consumption of natural gas boilers has been modified to account for a Lower Heating Value of 39MJ/m3 of natural gas, high pressure and natural gas, low pressure. In the datasets of Table 3, the input of natural gas has been adjusted by a factor of 39/36.3.

***Table 3. Modifications in heat production datasets.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity Name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| heat production, natural gas, at boiler atm. low-NOx condensing non-modulating <100kW | Europe without Switzerland; GLO | 1990-2000 | heat, central or small-scale, natural gas | MJ |
| heat production, natural gas, at boiler atmospheric low-NOx non-modulating <100kW | Europe without Switzerland; GLO | 1990-2000 | heat, central or small-scale, natural gas | MJ |
| heat production, natural gas, at boiler atmospheric non-modulating <100kW | Europe without Switzerland; GLO | 2000-2000 | heat, central or small-scale, natural gas | MJ |
| heat production, natural gas, at boiler condensing modulating <100kW | CH; Europe without Switzerland; GLO | 2000-2000 | heat, central or small-scale, natural gas | MJ |
| heat production, natural gas, at boiler condensing modulating >100kW | Europe without Switzerland; GLO | 2000-2000 | heat, district or industrial, natural gas | MJ |
| heat production, natural gas, at boiler condensing modulating >100kW | CA-QC | 2000-2015 | heat, district or industrial, natural gas | MJ |
| heat production, natural gas, at boiler fan burner low-NOx non-modulating <100kW | Europe without Switzerland; GLO | 1990-2000 | heat, central or small-scale, natural gas | MJ |
| heat production, natural gas, at boiler fan burner non-modulating <100kW | Europe without Switzerland; GLO | 2000-2000 | heat, central or small-scale, natural gas | MJ |
| heat production, natural gas, at boiler modulating <100kW | Europe without Switzerland; GLO | 2000-2000 | heat, central or small-scale, natural gas | MJ |
| heat production, natural gas, at boiler modulating >100kW | Europe without Switzerland; GLO | 2000-2000 | heat, district or industrial, natural gas | MJ |
| heat production, natural gas, at boiler modulating >100kW | CA-QC | 2000-2015 | heat, district or industrial, natural gas | MJ |
| heat production, natural gas, at diffusion absorption heat pump 4kW, future | CH; GLO | 2000-2005 | heat, future | MJ |
| heat production, natural gas, at industrial furnace >100kW | Europe without Switzerland; GLO | 2000-2000 | heat, district or industrial, natural gas | MJ |
| heat production, natural gas, at industrial furnace >100kW | CA-QC | 2000-2015 | heat, district or industrial, natural gas | MJ |
| heat production, natural gas, at industrial furnace low-NOx >100kW | Europe without Switzerland; GLO | 1990-2000 | heat, district or industrial, natural gas | MJ |
| heat production, natural gas, at industrial furnace low-NOx >100kW | CA-QC | 1990-2015 | heat, district or industrial, natural gas | MJ |

## 2.4 Resource corrections for Carbon, non-fossil

In the ecoinvent database, datasets with multiple products are allocated in the attributional system models, most frequently using price. When products have large difference in value, this leads to an allocation of most of the impacts to the more valuable product and can lead to a discrepancy between the biogenic carbon content of a product and the amount allocated to it based on the life cycle inventory. The resource corrections for carbon, non-fossil address this issue for the wood and paper sector. In the following sections, the calculation of the correction, adjusted datasets and final affected datasets are described. The corrections were applied only in the cut-off and EN15804 system models.

For the selected datasets from the wood and paper sectors the balance of non-fossil carbon was compared before and after the linking of the datasets. Ideally, the balance before linking is zero, however in many cases a small imbalance is already present in the undefined datasets. With the comparison of the undefined and linked datasets it can be determined how large of an imbalance in non-fossil carbon the allocation introduces. This imbalance is subsequently corrected by introducing a new exchange called “Carbon dioxide, non-fossil, resource correction” in the datasets. An additional step was taken after calculating the initial correction amounts by recalculating and checking the resulting life cycle inventories for cases where the changes lead to an overcorrection of the balance. This occurred due to the corrected datasets being connected to each other and the correction affecting each other. Thus, a second round of calculating the amounts was performed and their magnitude adjusted.

### 2.4.1 Corrected datasets

Complementing the balancing efforts performed for v3.7.1 in the wood and paper sectors, additional datasets were modified in order to harmonize the wood properties between datasets. Next to the imbalance in the datasets themselves, this is the second source of uncertainty for calculating the allocation correction amounts. For this release, efforts were concentrated on datasets that played a prominent role in the wood and paper sector. The affected datasets are listed in Table 4.

***Table 4. Datasets with modified properties in order to harmonise the properties across the supply change.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column.*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| EUR-flat pallet production | GLO; RER | 2000-2002 | EUR-flat pallet | unit |
| containerboard production, fluting medium, semichemical | GLO; RER | 2009-2015 | containerboard, fluting medium | kg |
| containerboard production, fluting medium, semichemical, 40% recycled content | CA-QC; GLO | 2009-2009 | containerboard, fluting medium | kg |
| cross-laminated timber production | GLO; RER | 2012-2012 | cross-laminated timber | m3 |
| glued laminated timber production, average glue mix | CA-QC | 2009-2011 | glued laminated timber, average glue mix | m3 |
| glued laminated timber production, average glue mix | Europe without Switzerland; GLO | 2012-2012 | glued laminated timber, average glue mix | m3 |
| glued solid timber production | GLO; RER | 2012-2012 | glued solid timber | m3 |
| planing, beam, hardwood, u=20% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, beam, hardwood, dried (u=20%), planed | m3 |
| plywood production | CA-QC; GLO; RER | 2012-2012 | plywood | m3 |
| sawing and planing, paraná pine, kiln dried | GLO | 1999-2005 | sawnwood, paraná pine, dried (u=10%) | m3 |

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| sawing and planing, paraná pine, kiln dried | BR | 2000-2005 | sawnwood, paraná pine, dried (u=10%) | m3 |
| sawing, hardwood | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, hardwood, raw | m3 |
| sawing, softwood | CA-QC | 2006-2012 | sawnwood, softwood, raw | m3 |
| sawing, softwood | CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, softwood, raw | m3 |
| sawlog and veneer log, hardwood, measured as solid wood under bark, import from Europe without Switzerland | CH | 2019-2019 | sawlog and veneer log, hardwood, measured as solid wood under bark | m3 |
| sawlog and veneer log, softwood, measured as solid wood under bark, import from Europe without Switzerland | CH | 2019-2019 | sawlog and veneer log, softwood, measured as solid wood under bark | m3 |
| sawnwood production, hardwood, dried (u=10%), planed | CH; Europe without Switzerland; GLO | 2014-2014 | sawnwood, hardwood, dried (u=10%), planed | m3 |
| sawnwood production, hardwood, dried (u=20%), planed | CH; Europe without Switzerland; GLO | 2014-2014 | sawnwood, hardwood, dried (u=20%), planed | m3 |
| sawnwood production, hardwood, raw, dried (u=10%) | CH; Europe without Switzerland; GLO | 2014-2014 | sawnwood, hardwood, raw, dried (u=10%) | m3 |
| sawnwood production, hardwood, raw, dried (u=20%) | CH; Europe without Switzerland; GLO | 2014-2014 | sawnwood, hardwood, raw, dried (u=20%) | m3 |
| sawnwood production, softwood, dried (u=10%), planed | CH; Europe without Switzerland; GLO | 2014-2014 | sawnwood, softwood, dried (u=10%), planed | m3 |
| sawnwood production, softwood, raw, dried (u=10%) | CH; Europe without Switzerland; GLO | 2014-2014 | sawnwood, softwood, raw, dried (u=10%) | m3 |
| sawnwood production, softwood, raw, dried (u=20%) | CH; Europe without Switzerland; GLO | 2014-2014 | sawnwood, softwood, raw, dried (u=20%) | m3 |
| structural timber production | GLO; RER | 2012-2012 | structural timber | m3 |
| sulfate pulp production, from hardwood, bleached | CA-QC | 2011-2012 | sulfate pulp, bleached | kg |
| sulfate pulp production, from hardwood, bleached | GLO | 2011-2021 | sulfate pulp, bleached | kg |
| sulfate pulp production, from hardwood, bleached | RER | 2017-2020 | sulfate pulp, bleached | kg |
| three and five layered board production | GLO; RER | 2012-2012 | three and five layered board | m3 |

### 2.4.2 Added correcting flows

Table 5 lists all datasets to which a correcting exchange “Carbon dioxide, non-fossil, resource correction” was added. A threshold of 1e-06 was applied filter unnecessarily small correction flows.

***Table 5. Datasets to which the resource correction flow “Carbon dioxide, non-fossil, resource correction” was added.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column.*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| containerboard production, fluting medium, semichemical, 40% recycled content | CA-QC; GLO | 2009-2009 | containerboard, fluting medium | kg |
| containerboard production, linerboard, kraftliner | CA-QC; GLO; RER | 2009-2015 | containerboard, linerboard | kg |
| corrugated board box production | RER | 2009-2015 | corrugated board box | kg |
| ethanol production from wood | CH; GLO | 1999-2006 | ethanol, without water, in 95% solution state, from fermentation | kg |
| ethanol production from wood | SE | 2000-2008 | ethanol, without water, in 95% solution state, from fermentation | kg |
| fibreboard production, hard | RER | 2012-2012 | fibreboard, hard | m3 |
| fibreboard production, soft, from wet & dry processes | CA-QC; Europe without Switzerland; GLO | 2012-2012 | fibreboard, soft | m3 |
| folding boxboard carton production | RER | 2018-2018 | folding boxboard carton | kg |
| glued laminated timber production, MUF-glue | CH; GLO | 2018-2018 | glued laminated timber, MUF-glue | m3 |
| glued laminated timber production, PUR-glue | CH; GLO | 2018-2018 | glued laminated timber, PUR-glue | m3 |
| glued laminated timber production, average glue mix | CA-QC | 2009-2011 | glued laminated timber, average glue mix | m3 |
| glued laminated timber production, average glue mix | Europe without Switzerland; GLO | 2012-2012 | glued laminated timber, average glue mix | m3 |
| oriented strand board production | CA-QC | 2005-2006 | oriented strand board | m3 |
| planing, beam, hardwood, u=10% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, beam, hardwood, dried (u=10%), planed | m3 |
| planing, beam, hardwood, u=20% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, beam, hardwood, dried (u=20%), planed | m3 |
| planing, beam, softwood, u=10% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, beam, softwood, dried (u=10%), planed | m3 |
| planing, beam, softwood, u=20% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, beam, softwood, dried (u=20%), planed | m3 |
| planing, board, hardwood, u=10% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, board, hardwood, dried (u=10%), planed | m3 |
| planing, board, hardwood, u=20% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, board, hardwood, dried (u=20%), planed | m3 |
| planing, board, softwood, u=10% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, board, softwood, dried (u=10%), planed | m3 |
| planing, board, softwood, u=20% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, board, softwood, dried (u=20%), planed | m3 |
| planing, lath, hardwood, u=10% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, lath, hardwood, dried (u=10%), planed | m3 |
| planing, lath, hardwood, u=20% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, lath, hardwood, dried (u=20%), planed | m3 |

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| planing, lath, softwood, u=10% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, lath, softwood, dried (u=10%), planed | m3 |
| planing, lath, softwood, u=20% | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, lath, softwood, dried (u=20%), planed | m3 |
| plywood production | CA-QC; GLO; RER | 2012-2012 | plywood | m3 |
| sawing and planing, paraná pine, kiln dried | BR | 2000-2005 | sawnwood, paraná pine, dried (u=10%) | m3 |
| sawing, hardwood | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, hardwood, raw | m3 |
| sawing, softwood | CA-QC | 2006-2012 | sawnwood, softwood, raw | m3 |
| sawing, softwood | CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, softwood, raw | m3 |
| solid bleached and unbleached board carton production | CA-QC; GLO; RER | 2018-2018 | solid bleached and unbleached board carton | kg |
| sulfate pulp production, from hardwood, bleached | RER | 2017-2020 | sulfate pulp, bleached | kg |
| window frame production, wood, U=1.5 W/m2K | CA-QC; GLO; RER | 1996-2004 | window frame, wood, U=1.5 W/m2K | m2 |
| wood cladding production, softwood | CA-QC; GLO | 2012-2012 | wood cladding, softwood | m2 |
| wood wool production | CA-QC; GLO; RER | 2002-2002 | wood wool | kg |

## 2.5 Impact Assessment Methods

For the ecoinvent database v3.8, three methods were added:

- EF v3.0
- EF v3.0 EN15804
- CML v4.8 2016

Furthermore, two methods were updated:

- EF v2.0 2018 (previously named “EF2.0 midpoint”)
- IPCC 2013

### 2.5.1 EF v3.0

The implementation of EF v3.0 is based on the “GLAD EF mapping project”[1] with some adaptations (Sonderegger & Bourgault, 2021).

### 2.5.2 EF v3.0 EN15804

The implementation of EF v3.0 EN15804 is based on the implementation of EF v3.0. The only difference is the way carbon dioxide is handled: the characterisation factors of biogenic $CO_2$ are "-1" ($CO_2$ uptake) and "+1" ($CO_2$ release) instead of “0” for EF v3.0.

[1] https://ecoinvent.org/activities/projects/global-lca-data-access-network/

### 2.5.3 EF v2.0 2018

EF v2.0 is the predecessor of EF v3.0. The naming of the method and of the impact categories and indicators were aligned with EF v3.0 (Table 6 and Table 7). The mapping of elementary exchanges to characterization factors was not updated to the "GLAD EF mapping"[2] that was used for EF v3.0 (see 2.5.1), so comparisons between EF v2.0 and EF v3.0 are possible but need careful evaluation. Furthermore, characterization factors for new elementary exchanges were added as mapped in Table 8.

***Table 6 Updated category names in EF v2.0 2018***

| **EF v2.0 2018 / ecoinvent 3.8** | **EF2.0 midpoint / ecoinvent 3.7.1** | |
|---|---|---|
| Category | Category | Indicator |
| acidification | ecosystem quality | freshwater and terrestrial acidification |
| climate change | climate change | climate change total |
| climate change: biogenic | climate change | climate change biogenic |
| climate change: fossil | climate change | climate change fossil |
| climate change: land use and land use change | climate change | climate change land use and land use change |
| ecotoxicity: freshwater | ecosystem quality | freshwater ecotoxicity |
| energy resources: non-renewable | resources | fossils |
| eutrophication: freshwater | ecosystem quality | freshwater eutrophication |
| eutrophication: marine | ecosystem quality | marine eutrophication |
| eutrophication: terrestrial | ecosystem quality | terrestrial eutrophication |
| human toxicity: carcinogenic | human health | carcinogenic effects |
| human toxicity: non-carcinogenic | human health | non-carcinogenic effects |
| ionising radiation: human health | human health | ionising radiation |
| land use | resources | land use |
| material resources: metals/minerals | resources | minerals and metals |
| ozone depletion | human health | ozone layer depletion |
| particulate matter formation | human health | respiratory effects, inorganics |
| photochemical ozone formation: human health | human health | photochemical ozone creation |
| water use | resources | dissipated water |

***Table 7 Updated indicator names in EF v2.0 2018***

| **EF v2.0 2018 / ecoinvent 3.8** | **EF2.0 midpoint / ecoinvent 3.7.1** |
|---|---|
| accumulated exceedance (ae) | freshwater and terrestrial acidification |
| global warming potential (GWP100) | climate change total |
| global warming potential (GWP100) | climate change biogenic |
| global warming potential (GWP100) | climate change fossil |
| global warming potential (GWP100) | climate change land use and land use change |
| comparative toxic unit for ecosystems (CTUe) | freshwater ecotoxicity |
| abiotic depletion potential (ADP): fossil fuels | fossils |
| fraction of nutrients reaching freshwater end compartment (P) | freshwater eutrophication |

[2] https://ecoinvent.org/activities/projects/global-lca-data-access-network/

| EF v2.0 2018 / ecoinvent 3.8 | EF2.0 midpoint / ecoinvent 3.7.1 |
|---|---|
| fraction of nutrients reaching marine end compartment (N) | marine eutrophication |
| accumulated exceedance (AE) | terrestrial eutrophication |
| comparative toxic unit for human (CTUh) | carcinogenic effects |
| comparative toxic unit for human (CTUh) | non-carcinogenic effects |
| human exposure efficiency relative to u235 | ionising radiation |
| soil quality index | land use |
| abiotic depletion potential (ADP): elements (ultimate reserves) | minerals and metals |
| ozone depletion potential (ODP) | ozone layer depletion |
| impact on human health | respiratory effects, inorganics |
| tropospheric ozone concentration increase | photochemical ozone creation |
| user deprivation potential (deprivation-weighted water consumption) | dissipated water |

***Table 8 Mapping of new elementary exchanges to EF v2.0 2018***

| Elementary exchange in v3.8 | Elementary exchange in EF v2.0 2018 |
|---|---|
| Azoxystrobin | azoxystrobin |
| Benzovindiflupyr | |
| Carbon dioxide, non-fossil, resource correction | |
| Carboxin | carboxin |
| Carfentrazone ethyl ester | carfentrazone-ethyl |
| Chlorantraniliprole | |
| Chlorfenapyr | |
| Chlorpyrifos | chlorpyrifos |
| Clethodim | clethodim |
| Deltamethrin | deltamethrin |
| Diflufenzopyr | |
| Dimethoate | dimethoate |
| Diquat dibromide | diquat dibromide |
| Ethaboxam | |
| Ethalfluralin | ethalfluralin |
| Fludioxonil | fludioxonil |
| Flumioxazin | flumioxazin |
| Fluxapyroxad | |
| Glufosinate ammonium | glufosinate ammonium salt |
| Imazamox | imazamox |
| Imazethapyr | pursuit |
| Imidacloprid | imidacloprid |
| Metalaxyl-M | mefenoxam |
| Metribuzin | metribuzin |
| N-methyl-2-pyrrolidone | 1-methyl-2-pyrrolidone |
| Oxygen | |
| Penflufen | |
| Pyraflufen-ethyl | |
| Pyroxasulfone | |
| Quizalofop-ethyl | quizalofop-ethyl |

| Elementary exchange in v3.8 | Elementary exchange in EF v2.0 2018 |
|---|---|
| Saflufenacil | |
| Sedaxane | |
| Sethoxydim | sethoxydim |
| Sulfentrazone | sulfentrazone |
| Thiabendazole | thiabendazole |
| Thiamethoxam | |
| Thiram | thiram |
| Triallate | triallate |
| Tribenuron-methyl | tribenuron-methyl |
| Triethylammonium | |
| Trifluralin | trifluralin |

### 2.5.4 IPCC 2013

Two characterization factors for “VOC, volatile organic compounds, unspecified origin” were corrected for the IPCC 2013 method (Table 9).

***Table 9 Updated characterization factors (CF) for the IPCC 2013***

| Elementary Exchange | Indicator | CF 3.8 | CF 3.7.1 |
|---|---|---|---|
| VOC, volatile organic compounds, unspecified origin | GTP 100a | 0.66 | 0.558624 |
| VOC, volatile organic compounds, unspecified origin | GWP 100a | 4.5 | 3.9762 |

# 3 Comfort features for users

This section describes updates implemented in order to improve the user experience and increase the comfort of use of the database. All the updates listed below refer to data already published in v.3.7.1. Newly added data v3.8 already conform to the proper documentation.

## 3.1 ISIC classifications

Activities are classified based on the ISIC (International Standard Industrial Classification) classification from United Nations that classify all economic activities. 3043 activities have had their ISIC classification updated. This has corrected certain inconsistencies and has homogenised activities so users can find them faster and more accurately.

## 3.2 CAS numbers

The CAS registry number has been updated in 414 elementary exchanges where 363 refer to an addition of a CAS number. Regarding intermediate exchanges, 356 CAS numbers were updated in 3.8, 307 of those refer to a CAS number addition. Further, updates were performed to formulas and synonyms of elementary exchanges mostly linked to the modification of CAS numbers.

## 3.3 Product information

This update offers comfort to users while employing the ecoinvent database. Overall, v3.8 contains 3291 unique products. By the term “product” herein, we refer to “Reference product”, either those being physical products or refer to the provision of a service. The update documents and defines the products from a user perspective to help them identify products suitable for what they wish to model.

### 3.3.1 Products

Products are generally easier to describe, they are defined from a physical perspective and key properties are presented, defining the product relative to its appearance, dimensions and other physical characteristics. However, the product information of products strictly reflects the product as it is produced from processes available in the database. For example, ammonia, is a widely produced chemical and in the database, it is produced by either natural gas or hard coal as the main carbon inputs to the chemical process. Hence, the product information refers only to the specific production processes accommodated in the database. Therefore, the product information alone, is not always sufficient, the user needs to assess this information alongside the data available within the database.

Some key characteristics about products that fall under broad sectors are the following

- Immobile infrastructure is strictly mentioned in the product information and specific properties are shown related to lifetime and lifetime capacity - when this is relevant.
- All chemical products show specific information such as, their CAS number, the IUAC name, origin of the substance (organic or inorganic), modelling of the substance (pure or diluted substance) and finally consumer use and industrial application. If relevant, the substance is also labelled based on the nutrient content (Nitrogen, Phosphorus and Potassium) they contain.

- Agricultural products and crops are only characterised based on their life cycle (annual-perennial). Processed agricultural products mention their origin and how they are produced in the database while agricultural services give guidance to users on how to employ them.
- A physical description accompanies all building materials while their use of the product within a building is also documented.
- Fuels are presented with a physical and/or chemical description along with information about the lower heating value they have.
- Pulp and paper, wood and textile products as well as plastics and packaging materials are described in terms of their physical properties and characteristics and also guidance is given on how the products should be used in different supply chains or modelling cases.
- Waste and recyclable materials along with electronics and metal products are not described for v3.8, users may find specific information about them on the datasets that are producing or treating them.
- Finally, heat and electricity describe the characteristic of the energy provided and how this is produced when relevant.

### 3.3.2 Services

Products that refer to service provision may not always be intuitive in terms of what they include or model, especially because there is no physical link of what is produced. In that case, the unit of the service offered may not be intuitive directly. The product information offers a service description that helps users understand the most crucial parameters related to the provision of a service. Additionally, guidance is offered to the users on how the product should be used within their models.

In other cases, a detailed description of what is required to provide a service, is offered within the product information. This aims mostly at informing the user of the system boundaries of the process providing the service. In those cases, the information is displayed to the user to facilitate any modification of the dataset, should that be required. This can be the case for certain infrastructure products.

Transport services are describing the node of transport offered and parameters relevant to the service. Similarly, metal services (eg. hot rolling), describe how the service should be used with or without a metal input.

## 3.4 Documentation on market activities

Documentation work has been done in order to improve the metainformation in market activities in the database. With that purpose, all markets in the database have been analysed, the lacking information identified and added accordingly to the relevant fields. The metainformation fields analysed were: General Comment, Activity Start, Activity End.

Additionally, to all markets, a short descriptive text has been added in the General Comment defining the use, scope and function of markets, depending on the type of product supplied by the market (regular product, waste, service, infrastructure...).

# 4 New and Updated Supply Chains in Brazil

The *Cornerstone* project[3] was set up between Rede ACV (the Brazilian business network for LCA) and the ecoinvent association to improve the availability and access to background data on key supply chain for Brazil. Rede ACV, through its contractor ACV Brasil, departed from existing content in the ecoinvent database to develop regionalized life cycle inventory (LCI) data representative of the situation in Brazil. The data generated in this first phase of the Cornerstone project will be included both in the national LCI database SICV Brasil[4] as well as in the ecoinvent database (as described below), to the benefit of local users and the international LCA community alike.

## 4.1 Re-Contextualized Data for Brazil

The 're-contextualisation' of existing datasets in the ecoinvent database to reflect the supply chain situation in Brazil is described in detail in Valebona et al. (2021). This approach allowed the data providers to focus their efforts on gathering country-specific data and adapt the modelling of the most relevant inventory items, e.g., based on contribution analysis. The data submission for version 3.8 (listed in Table 10) encompassed the extraction, import and distribution of crude petroleum oil and natural gas, production of biodiesel (thorough the esterification of vegetable oils and animal fats to fatty acid methyl ester, FAME), regional distribution of diesel (for transport), and road freight transport by lorry. A summary of the respective aspects addressed during the 're-contextualization' of these activities for Brazil is available on Rede ACV's project website.[5]

***Table 10. New and 're-contextualized' activities for improved representation of selected Brazilian supply chains.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column. In the column v.3.8, "N" stands for "New Activity", "U" stands for "Updated Activity"; "M" for datasets where mathematical formulas have been recalculated.*

| Activity name | Geography | Time Period | Product Name | Unit | v3.8 |
|---|---|---|---|---|---|
| esterification of vegetable oils and animal fats, average mix | BR; GLO | 2018-2018 | fatty methyl acid esters | kg | N |
| evaporation of natural gas | BR | 2018-2021 | natural gas | $m^3$ | N |
| market for diesel | BR | 2018-2018 | diesel | kg | U |
| market for fatty acid methyl ester | BR | 2018-2018 | fatty methyl acid esters | kg | N |
| market for natural gas, high pressure | BR | 2018-2021 | natural gas | $m^3$ | N |
| natural gas, high pressure, import from BO | BR; GLO | 2018-2021 | natural gas | $m^3$ | N |
| petroleum and gas production, off-shore | BR | 2018-2021 | petroleum; natural gas | kg; $m^3$ | N |
| petroleum and gas production, on-shore | BO; BR | 2018-2021 | petroleum; natural gas | kg; $m^3$ | N |
| transport, freight, lorry 16-32 metric ton, EURO1 | BR | 2020-2021 | transport, freight, lorry 16-32 metric ton, EURO1 | tkm | N |
| transport, freight, lorry 16-32 metric ton, EURO2 | BR | 2020-2021 | transport, freight, lorry 16-32 metric ton, EURO2 | tkm | N |
| transport, freight, lorry 16-32 metric ton, EURO3 | BR | 2020-2021 | transport, freight, lorry 16-32 metric ton, EURO3 | tkm | N |
| transport, freight, lorry 16-32 metric ton, EURO5 | BR | 2020-2021 | transport, freight, lorry 16-32 metric ton, EURO5 | tkm | N |
| transport, freight, lorry 16-32 metric ton, unregulated | BR | 2020-2021 | transport, freight, lorry 16-32 metric ton, unregulated | tkm | N |

[3] https://www.ecoinvent.org/about/projects/cornerstone/institutional-partnership-with-rede-acv-in-brazil.html

[4] https://sicv.acv.ibict.br/Node/

[5] https://redeacv.org.br/en/wg-database/ [assessed on 2021-09-09]

| Activity name | Geography | Time Period | Product Name | Unit | v3.8 |
|---|---|---|---|---|---|
| transport, freight, lorry 3.5-7.5 metric ton, EURO1 | BR | 2020-2021 | transport, freight, lorry 3.5-7.5 metric ton, EURO1 | tkm | N |
| transport, freight, lorry 3.5-7.5 metric ton, EURO2 | BR | 2020-2021 | transport, freight, lorry 3.5-7.5 metric ton, EURO2 | tkm | N |
| transport, freight, lorry 3.5-7.5 metric ton, EURO3 | BR | 2020-2021 | transport, freight, lorry 3.5-7.5 metric ton, EURO3 | tkm | N |
| transport, freight, lorry 3.5-7.5 metric ton, EURO5 | BR | 2020-2021 | transport, freight, lorry 3.5-7.5 metric ton, EURO5 | tkm | N |
| transport, freight, lorry 3.5-7.5 metric ton, unregulated | BR | 2020-2021 | transport, freight, lorry 3.5-7.5 metric ton, unregulated | tkm | N |
| transport, freight, lorry 7.5-16 metric ton, EURO1 | BR | 2020-2021 | transport, freight, lorry 7.5-16 metric ton, EURO1 | tkm | N |
| transport, freight, lorry 7.5-16 metric ton, EURO2 | BR | 2020-2021 | transport, freight, lorry 7.5-16 metric ton, EURO2 | tkm | N |
| transport, freight, lorry 7.5-16 metric ton, EURO3 | BR | 2020-2021 | transport, freight, lorry 7.5-16 metric ton, EURO3 | tkm | N |
| transport, freight, lorry 7.5-16 metric ton, EURO5 | BR | 2020-2021 | transport, freight, lorry 7.5-16 metric ton, EURO5 | tkm | N |
| transport, freight, lorry 7.5-16 metric ton, unregulated | BR | 2020-2021 | transport, freight, lorry 7.5-16 metric ton, unregulated | tkm | N |
| transport, freight, lorry >32 metric ton, EURO1 | BR | 2020-2021 | transport, freight, lorry >32 metric ton, EURO1 | tkm | N |
| transport, freight, lorry >32 metric ton, EURO2 | BR | 2020-2021 | transport, freight, lorry >32 metric ton, EURO2 | tkm | N |
| transport, freight, lorry >32 metric ton, EURO3 | BR | 2020-2021 | transport, freight, lorry >32 metric ton, EURO3 | tkm | N |
| transport, freight, lorry >32 metric ton, EURO5 | BR | 2020-2021 | transport, freight, lorry >32 metric ton, EURO5 | tkm | N |
| transport, freight, lorry >32 metric ton, unregulated | BR | 2020-2021 | transport, freight, lorry >32 metric ton, unregulated | tkm | N |

Regional market activities for each of the transport activities listed in Table 10 were also created, and subsequently linked (proportionally to the respective annual production volumes) to a generic road freight transport service, available from 'market for transport, freight, lorry, unspecified' in Brazil (Table 11). This activity replaces the corresponding activity for RoW for any input of road freight transport to regional markets in Brazil or in the Region of Latin America (RLA).

***Table 11. New markets and 'renaming' activities for road freight transport in Brazil****. If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| market for transport, freight, lorry 16-32 metric ton, EURO1 | BR | 2019-2019 | transport, freight, lorry 16-32 metric ton, EURO1 | tkm |
| market for transport, freight, lorry 16-32 metric ton, EURO2 | BR | 2019-2019 | transport, freight, lorry 16-32 metric ton, EURO2 | tkm |
| market for transport, freight, lorry 16-32 metric ton, EURO3 | BR | 2011-2011 | transport, freight, lorry 16-32 metric ton, EURO3 | tkm |
| market for transport, freight, lorry 16-32 metric ton, EURO5 | BR | 2011-2011 | transport, freight, lorry 16-32 metric ton, EURO5 | tkm |
| market for transport, freight, lorry 16-32 metric ton, unregulated | BR | 2019-2019 | transport, freight, lorry 16-32 metric ton, unregulated | tkm |
| market for transport, freight, lorry 3.5-7.5 metric ton, EURO1 | BR | 2019-2019 | transport, freight, lorry 3.5-7.5 metric ton, EURO1 | tkm |
| market for transport, freight, lorry 3.5-7.5 metric ton, EURO2 | BR | 2019-2019 | transport, freight, lorry 3.5-7.5 metric ton, EURO2 | tkm |

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| market for transport, freight, lorry 3.5-7.5 metric ton, EURO3 | BR | 2011-2011 | transport, freight, lorry 3.5-7.5 metric ton, EURO3 | tkm |
| market for transport, freight, lorry 3.5-7.5 metric ton, EURO5 | BR | 2011-2011 | transport, freight, lorry 3.5-7.5 metric ton, EURO5 | tkm |
| market for transport, freight, lorry 3.5-7.5 metric ton, unregulated | BR | 2019-2019 | transport, freight, lorry 3.5-7.5 metric ton, unregulated | tkm |
| market for transport, freight, lorry 7.5-16 metric ton, EURO1 | BR | 2019-2019 | transport, freight, lorry 7.5-16 metric ton, EURO1 | tkm |
| market for transport, freight, lorry 7.5-16 metric ton, EURO2 | BR | 2019-2019 | transport, freight, lorry 7.5-16 metric ton, EURO2 | tkm |
| market for transport, freight, lorry 7.5-16 metric ton, EURO3 | BR | 2011-2011 | transport, freight, lorry 7.5-16 metric ton, EURO3 | tkm |
| market for transport, freight, lorry 7.5-16 metric ton, EURO5 | BR | 2011-2011 | transport, freight, lorry 7.5-16 metric ton, EURO5 | tkm |
| market for transport, freight, lorry 7.5-16 metric ton, unregulated | BR | 2019-2019 | transport, freight, lorry 7.5-16 metric ton, unregulated | tkm |
| market for transport, freight, lorry >32 metric ton, EURO1 | BR | 2019-2019 | transport, freight, lorry >32 metric ton, EURO1 | tkm |
| market for transport, freight, lorry >32 metric ton, EURO2 | BR | 2019-2019 | transport, freight, lorry >32 metric ton, EURO2 | tkm |
| market for transport, freight, lorry >32 metric ton, EURO3 | BR | 2011-2011 | transport, freight, lorry >32 metric ton, EURO3 | tkm |
| market for transport, freight, lorry >32 metric ton, EURO5 | BR | 2011-2011 | transport, freight, lorry >32 metric ton, EURO5 | tkm |
| market for transport, freight, lorry >32 metric ton, unregulated | BR | 2019-2019 | transport, freight, lorry >32 metric ton, unregulated | tkm |
| market for transport, freight, lorry, unspecified | BR | 2019-2019 | transport, freight, lorry, unspecified | tkm |

Three main factors explain most of the difference in results between the road freight transport activities in Brazil and the corresponding RoW for several important impact categories (Figure 4), namely i., the supply of crude oil for domestic petroleum refineries, ii., the mandatory blend-in of biodiesel into regular diesel for transport in Brazil, and iii. differences in load factors of the vehicles. The country-specific supply of crude petroleum oil for refineries is discussed in the section below, and the data and assumptions related to average load factors in Brazil is presented in Valebona et al. (2021).

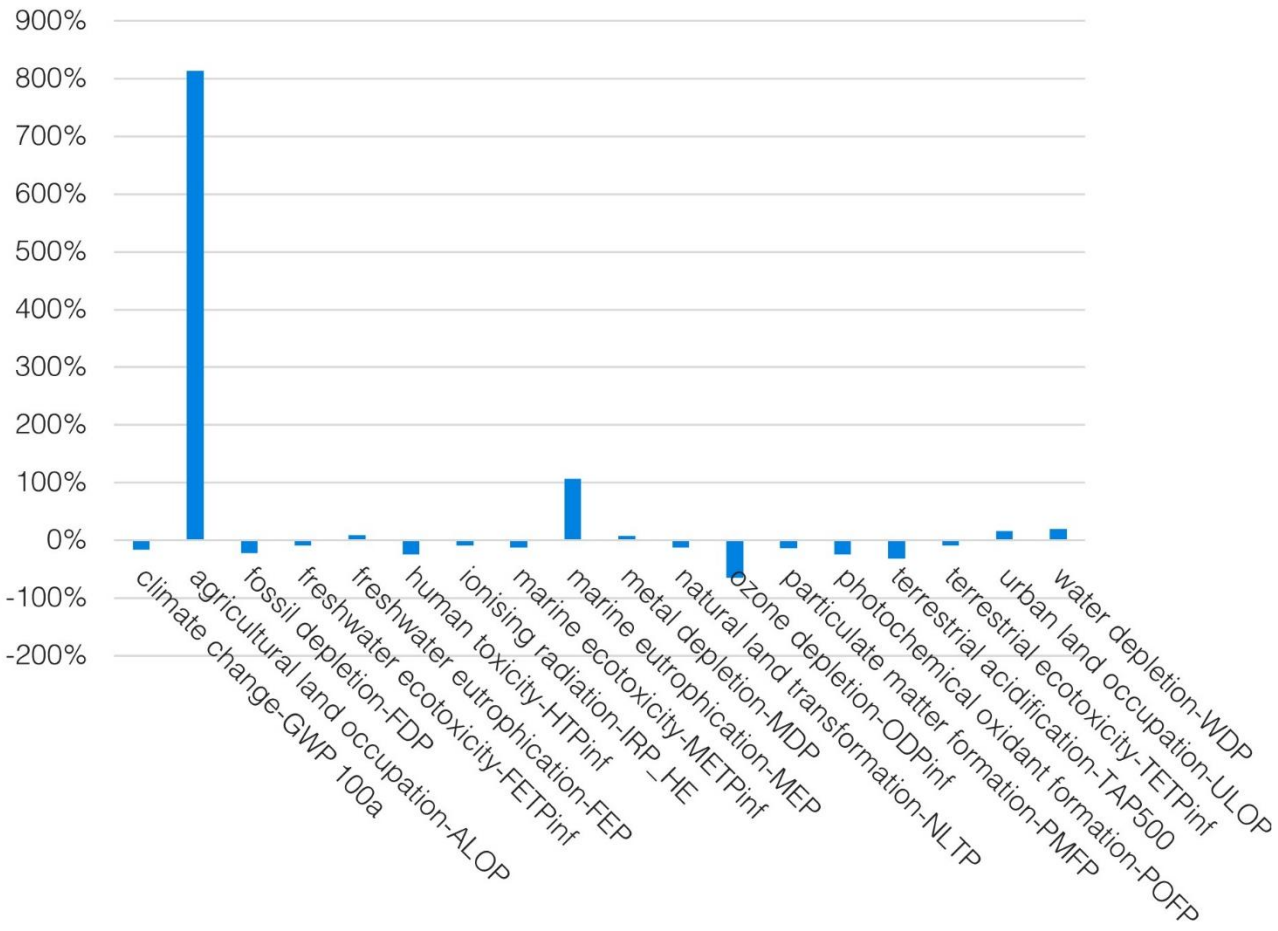


***Figure 4. Comparison of impacts from 'market for transport, freight, lorry, unspecified' in Brazil (BR) versus Rest-of-the-World (RoW) for selected LCIA categories.*** *The results were derived based on the ReCiPe method (v1.13; Egalitarian prespective, midpoints), except for climate change (GWP 100a), which was obtained from ecoinvent's implementation IPCC (2013).*

Since 2008, it is mandatory to blend road diesel with biodiesel in Brazil, with the share of biofuel increased progressively, reaching 12% in 2020. This blend-in (modelled here as an input of 'fatty methyl acid ester', FAME) makes the inventories of these new Brazilian activities stand apart from road freight transport in other geographies, particularly in terms of impacts in categories such as agricultural land occupation and marine eutrophication (Figure 4). These differences can be traced back to the production of soybeans and the extensive use of soybean oil in the average feedstock mix for the esterification of vegetable oils and animal fats in Brazil. The new esterification dataset was created with LCI data from 19 Brazilian biodiesel producers certified under the National Biofuel Policy (*RenovaBio*). At the other end of the 'pipe', the influence of the 12% biodiesel on the fuel-dependent exhaust emissions were accounted for using correction factors derived from U.S. EPA (2002).

## 4.2 Crude Oil Supply for Petroleum Refinery Operation in Brazil

The activities listed in Table 12 already existed in earlier versions of the ecoinvent database but have been updated for version 3.8 to better reflect the country-specific supply of crude petroleum oil to petroleum refinery operation in Brazil. Direct activity links were set for input of petroleum (crude oil) to link refinery operation in Brazil to supply from domestic onshore/offshore oil production. The relative input shares were derived from national statistics (ANP 2019), based on total inland production and gross imports, resulting in

89.6% and 4.0% from domestic offshore and onshore production, respectively, and the remain 6.3% from imports (i.e., provided by the market activity for petroleum in GLO). This motivation is also provided in the comment fields for relevant exchanges in the respective datasets.

***Table 12. Updated activities for petroleum refinery operation in Brazil.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| base oil production, petroleum refinery operation | BR | 2014-2017 | base oil | kg |
| C3 hydrocarbon production, mixture, petroleum refinery operation | BR | 2014-2017 | C3 hydrocarbon mixture | kg |
| diesel production, low-sulfur, petroleum refinery operation | BR | 2014-2017 | diesel, low-sulfur | kg |
| diesel production, petroleum refinery operation | BR | 2014-2017 | diesel | kg |
| heavy fuel oil production, petroleum refinery operation | BR | 2014-2017 | heavy fuel oil | kg |
| hydrogen production, gaseous, petroleum refinery operation | BR | 2014-2017 | hydrogen, gaseous | kg |
| kerosene production, petroleum refinery operation | BR | 2014-2017 | kerosene | kg |
| light fuel oil production, petroleum refinery operation | BR | 2014-2017 | light fuel oil | kg |
| liquefied petroleum gas production, petroleum refinery operation | BR | 2014-2017 | liquefied petroleum gas | kg |
| naphtha production, petroleum refinery operation | BR | 2014-2017 | naphtha | kg |
| petrol production, unleaded, petroleum refinery operation | BR | 2014-2017 | petrol, unleaded | kg |
| petroleum slack wax production, petroleum refinery operation | BR | 2014-2017 | petroleum slack wax | kg |
| pitch production, petroleum refinery operation | BR | 2014-2017 | pitch | kg |
| refinery gas production, petroleum refinery operation | BR | 2014-2017 | refinery gas | kg |
| reformate production, petroleum refinery operation | BR | 2014-2017 | reformate | kg |
| sulfur production, petroleum refinery operation | BR | 2014-2017 | sulfur | kg |
| white spirit production, petroleum refinery operation | BR | 2014-2017 | white spirit | kg |

The decision to link the petroleum refinery operation in Brazil to the new datasets for domestic onshore/offshore production also plays a role for some impact categories. With GLO market for petroleum now only representing a few percent of the refinery input to refineries in BR, not only the contribution from transoceanic transport but also the regional differences in the global market for petroleum, e.g., the contribution from production in Russia, affect the results.

### 4.3 Global lorry freight transport

The Cornerstone project introduces new data for freight transport by lorry in Brazil. Consequently, the corresponding global activities that exist as Rest-of-the-World (RoW) have been recalculated as weighted average of the regions available for the selected lorry size and EURO classes.

The production volumes of Global freight transport by lorry activities have also been revised. The production volume of Global activities is estimated based on the corresponding regional dataset(s). To do this, the total tonne-km [tkm] reported in the OECD data for freight transport[6] were used. Total tkm is

[6] https://data.oecd.org/transport/freight-transport.htm

reported for 50 countries. Data from 2019 was used wherever possible, previous years have been used to fill in gaps. Brazil is not part of OECD, the estimate of total tkm from the Cornerstone project was included in the calculation to derive the shares of Brazilian transport.

It is estimated that 10% of this transport is used for transport of goods in need of atmosphere control, thus this production volume is included in the "transport, freight, lorry [...] with refrigeration machine" datasets. The production volumes of refrigerated transport have therefore been updated as well.

***Table 13. Updated activities related to Global lorry freight transport.*** *"U" stands for "Updated Activity", "*" is used to indicate those activities that have been recalculated as weighted average compared to those that have been modified solely for the update of the production volumes.*

| Activity Name | Geography | Time Period | v3.8 |
|---|---|---|---|
| transport, freight, lorry 16-32 metric ton, EURO1 | GLO | 2017-2021 | U* |
| transport, freight, lorry 16-32 metric ton, EURO2 | GLO | 2017-2021 | U* |
| transport, freight, lorry 16-32 metric ton, unregulated | GLO | 2017-2021 | U* |
| transport, freight, lorry 3.5-7.5 metric ton, EURO1 | GLO | 2017-2021 | U* |
| transport, freight, lorry 3.5-7.5 metric ton, EURO2 | GLO | 2017-2021 | U* |
| transport, freight, lorry 3.5-7.5 metric ton, unregulated | GLO | 2017-2021 | U* |
| transport, freight, lorry 7.5-16 metric ton, EURO1 | GLO | 2017-2021 | U* |
| transport, freight, lorry 7.5-16 metric ton, EURO2 | GLO | 2017-2021 | U* |
| transport, freight, lorry 7.5-16 metric ton, unregulated | GLO | 2017-2021 | U* |
| transport, freight, lorry >32 metric ton, EURO1 | GLO | 2017-2021 | U* |
| transport, freight, lorry >32 metric ton, EURO2 | GLO | 2017-2021 | U* |
| transport, freight, lorry >32 metric ton, unregulated | GLO | 2017-2021 | U* |
| transport, freight, lorry, all sizes, EURO3 to generic market for transport, freight, lorry, unspecified | GLO | 2010-2015 | U |
| transport, freight, lorry, all sizes, EURO4 to generic market for transport, freight, lorry, unspecified | GLO | 2010-2015 | U |
| transport, freight, lorry, all sizes, EURO5 to generic market for transport, freight, lorry, unspecified | GLO | 2010-2015 | U |
| transport, freight, lorry 16-32 metric ton, EURO3 | GLO | 2009-2013 | U |
| transport, freight, lorry 16-32 metric ton, EURO4 | GLO | 2009-2013 | U |
| transport, freight, lorry 16-32 metric ton, EURO5 | GLO | 2009-2013 | U |
| transport, freight, lorry 16-32 metric ton, EURO6 | GLO | 2009-2013 | U |
| transport, freight, lorry 3.5-7.5 metric ton, EURO3 | GLO | 2009-2013 | U |
| transport, freight, lorry 3.5-7.5 metric ton, EURO4 | GLO | 2009-2013 | U |
| transport, freight, lorry 3.5-7.5 metric ton, EURO5 | GLO | 2009-2013 | U |
| transport, freight, lorry 3.5-7.5 metric ton, EURO6 | GLO | 2009-2013 | U |
| transport, freight, lorry 7.5-16 metric ton, EURO3 | GLO | 2009-2013 | U |
| transport, freight, lorry 7.5-16 metric ton, EURO4 | GLO | 2009-2013 | U |
| transport, freight, lorry 7.5-16 metric ton, EURO5 | GLO | 2009-2013 | U |
| transport, freight, lorry 7.5-16 metric ton, EURO6 | GLO | 2009-2013 | U |
| transport, freight, lorry >32 metric ton, EURO3 | GLO | 2009-2013 | U |
| transport, freight, lorry >32 metric ton, EURO4 | GLO | 2009-2013 | U |
| transport, freight, lorry >32 metric ton, EURO5 | GLO | 2009-2013 | U |
| transport, freight, lorry >32 metric ton, EURO6 | GLO | 2009-2013 | U |
| transport, freight, lorry, all sizes, EURO1 to generic market for transport, freight, lorry, unspecified | GLO | 2019-2019 | U |
| transport, freight, lorry, all sizes, EURO2 to generic market for transport, freight, lorry, unspecified | GLO | 2019-2019 | U |
| transport, freight, lorry, all sizes, EURO6 to generic market for transport, freight, lorry, unspecified | GLO | 2010-2015 | U |

| Activity Name | Geography | Time Period | v3.8 |
|---|---|---|---|
| transport, freight, lorry, all sizes, unregulated to generic market for transport, freight, lorry, unspecified | GLO | 2019-2019 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO3, R134a refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO3, R134a refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO3, carbon dioxide, liquid refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO3, carbon dioxide, liquid refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO4, R134a refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO4, R134a refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO4, carbon dioxide, liquid refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO4, carbon dioxide, liquid refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO5, R134a refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO5, R134a refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO5, carbon dioxide, liquid refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO5, carbon dioxide, liquid refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO6, R134a refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO6, R134a refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO6, carbon dioxide, liquid refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO6, carbon dioxide, liquid refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO3, R134a refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO3, R134a refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO3, carbon dioxide, liquid refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO3, carbon dioxide, liquid refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO4, R134a refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO4, R134a refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO4, carbon dioxide, liquid refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO4, carbon dioxide, liquid refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO5, R134a refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO5, R134a refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO5, carbon dioxide, liquid refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO5, carbon dioxide, liquid refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO6, R134a refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO6, R134a refrigerant, freezing | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO6, carbon dioxide, liquid refrigerant, cooling | GLO | 2010-2014 | U |
| transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO6, carbon dioxide, liquid refrigerant, freezing | GLO | 2010-2014 | U |

# 5 Agriculture sector

## 5.1 Agricultural data in Canada

The update was performed in collaboration with the University of British Columbia – Okanagan and the Food Systems PRISM Lab and resulted in the addition of a new products to the database (lentils) and to Canada specific (protein pea). Further, agricultural services, were recontextualised and adjusted to the Canadian production.

***Table 14. New activities added for v3.8 in the agriculture sector, related to Canadian production.***

| Activity Name | Geography | Time Period | Product | Unit |
|---|---|---|---|---|
| application of plant protection product, by field sprayer | Canada without Quebec | 2019-2019 | application of plant protection product, by field sprayer | ha |
| combine harvesting | Canada without Quebec | 2019-2019 | combine harvesting | ha |
| fertilising, by broadcaster | Canada without Quebec | 2019-2019 | fertilising, by broadcaster | ha |
| protein pea production | CA-AB; CA-MB; CA-SK | 2017-2019 | protein pea | kg |
| sowing | Canada without Quebec | 2019-2019 | sowing | ha |
| swath, by rotary windrower | Canada without Quebec | 2019-2019 | swath, by rotary windrower | ha |
| tillage, cultivating, chiselling | Canada without Quebec | 2019-2019 | tillage, cultivating, chiselling | ha |
| tillage, harrowing, by offset disc harrow | CA | 2019-2019 | tillage, harrowing, by offset disc harrow | ha |
| tillage, harrowing, by rotary harrow | CA | 2019-2019 | tillage, harrowing, by rotary harrow | ha |
| tillage, rolling | Canada without Quebec | 2019-2019 | tillage, rolling | ha |
| tillage, rotary cultivator | Canada without Quebec | 2019-2019 | tillage, rotary cultivator | ha |
| drying of lentils | CA-AB; CA-SK; GLO | 2019-2019 | drying of lentils | l |
| drying of protein pea | CA-AB; CA-MB; CA-SK; GLO | 2019-2019 | drying of protein pea | l |
| lentil production | CA-AB; CA-SK; GLO | 2017-2019 | lentil | kg |
| lentil seed production, for sowing | GLO | 1999-2002 | lentil seed, for sowing | kg |
| market for drying of lentils | GLO | 2019-2019 | drying of lentils | l |
| market for drying of protein pea | GLO | 2019-2019 | drying of protein pea | l |
| market for lentil | GLO | 2016-2017 | lentil | kg |
| market for lentil seed, for sowing | GLO | 1999-2002 | lentil seed, for sowing | kg |
| venting of carbon dioxide, in chemical industry | GLO | 2020-2020 | venting of carbon dioxide, in chemical industry | kg |

## 5.2 Other updates

Other updates and corrections (adjusting Production Volumes and market shares, linking to suppliers or markets in the value chain, improvements to the dataset) have been done to datasets belonging to this sector, they are reported in the following table.

***Table 15. Updated activities in the agricultural sector.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity Name | Geography | Time Period | Product | Unit |
|---|---|---|---|---|
| barley production | FR; GLO | 2000-2004 | barley grain | kg |
| palm fruit bunch production | GLO; MY | 2002-2006 | palm fruit bunch | kg |
| palm fruit bunch production | ID | 2009-2012 | palm fruit bunch | kg |
| peat moss production, horticultural use | CA-QC; GLO | 2010-2010 | peat moss | m3 |
| soybean meal and crude oil production | RER | 1998-1998 | soybean meal | kg |
| soybean meal and crude oil production | GLO | 1998-2007 | soybean meal | kg |
| soybean meal and crude oil production | US | 2007-2007 | soybean meal | kg |
| soybean meal and crude oil production | BR | 2015-2015 | soybean meal | kg |
| soybean meal and crude oil production, mechanical extraction | GLO | 2010-2013 | soybean meal | kg |
| soybean oil refinery operation | GLO | 2000-2008 | soybean oil, refined | kg |
| soybean oil refinery operation | US | 2000-2008 | soybean oil, refined | kg |
| wheat production | FR | 2000-2004 | wheat grain | kg |
| wheat production | GLO; US | 2001-2006 | wheat grain | kg |

# 6 Batteries

## 6.1 Li-Ion batteries

In ecoinvent v3.8 new datasets for three types of Li-Ion batteries are included. The full name and abbreviations are:

- Nickel-Cobalt-Aluminium-Oxide (NCA)
- Nickel-Manganese-Cobalt-Oxide 111 (NMC111)
- Nickel-Manganese-Cobalt-Oxide 811 (NMC811)

These datasets have been created by the Swiss Federal Laboratories for Materials Science and Technology (EMPA) and incorporate various chemicals such as cobalt sulfate, disodium disulphite, vinyl carbonate and oxides and hydroxides for the three battery types. The individual battery components (cathode, anode, high and low voltage systems, cells and battery management systems) are split, and each represented in their own dataset.

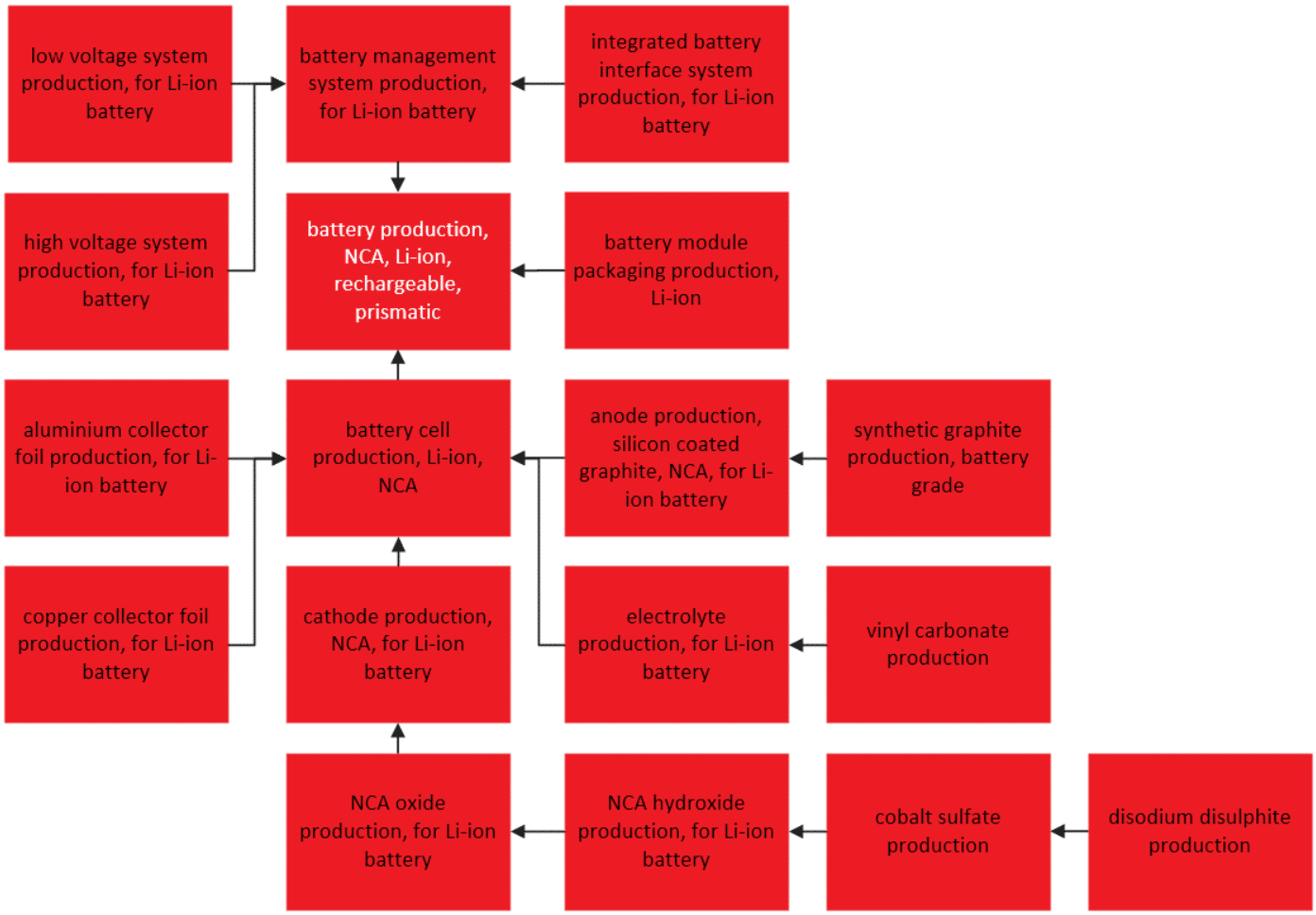


***Figure 5. Flowchart showing the connections between the newly added battery related datasets.*** *The name of the activity producing the main product is written in white. Datasets that are specifically labelled with "NCA" are also available for the other two types, NMC111 and NMC811.*

Figure 5 shows how the datasets for the NCA battery are connected (markets are not shown). Datasets that are specifically labelled with “NCA” are also available for the other two types, NMC111 and NMC811, as can be gathered from Table 16. Most of the datasets are modelled for China (CN), some were modelled as global (GLO) datasets. All datasets, except “battery separator production” are new datasets.

***Table 16. New datasets regarding the modelling of batteries in ecoinvent database v3.8.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column. In column v3.8, “U” stands for “Updated Activity”, and “N” stands for “New activity”.*

| Activity name | Geography | Time Period | Product Name | Unit | v3.8 |
|---|---|---|---|---|---|
| NCA hydroxide production, for Li-ion battery | CN; GLO | 2018-2020 | NCA hydroxide | kg | N |
| NCA oxide production, for Li-ion battery | CN; GLO | 2016-2020 | NCA oxide | kg | N |
| NMC111 hydroxide production, for Li-ion battery | CN; GLO | 2018-2020 | NMC111 hydroxide | kg | N |
| NMC111 oxide production, for Li-ion battery | CN; GLO | 2018-2020 | NMC111 oxide | kg | N |
| NMC811 hydroxide production, for Li-ion battery | CN; GLO | 2018-2020 | NMC811 hydroxide | kg | N |
| NMC811 oxide production, for Li-ion battery | CN; GLO | 2018-2020 | NMC811 oxide | kg | N |
| aluminium collector foil production, for Li-ion battery | GLO | 2010-2020 | aluminium collector foil, for Li-ion battery | kg | N |
| anode production, graphite, for Li-ion battery | CN; GLO | 2016-2020 | anode, graphite, for Li-ion battery | kg | N |
| anode production, silicon coated graphite, NCA, for Li-ion battery | CN; GLO | 2016-2020 | anode, silicon coated graphite, for Li-ion battery | kg | N |
| anode production, silicon coated graphite, NMC811, for Li-ion battery | CN; GLO | 2016-2020 | anode, silicon coated graphite, for Li-ion battery | kg | N |
| battery cell production, Li-ion, NCA | CN; GLO | 2017-2020 | battery cell, Li-ion, NCA | kg | N |
| battery cell production, Li-ion, NMC111 | CN; GLO | 2017-2020 | battery cell, Li-ion, NMC111 | kg | N |
| battery cell production, Li-ion, NMC811 | CN; GLO | 2017-2020 | battery cell, Li-ion, NMC811 | kg | N |
| battery management system production, for Li-ion battery | GLO | 2014-2020 | battery management system, for Li-ion battery | kg | N |
| battery module packaging production, Li-ion | CN; GLO | 2018-2020 | battery module packaging, Li-ion | kg | N |
| battery production, Li-ion, NMC111, rechargeable, prismatic | CN; GLO | 2017-2020 | battery, Li-ion, NMC111, rechargeable, prismatic | kg | N |
| battery production, NCA, Li-ion, rechargeable, prismatic | CN; GLO | 2017-2020 | battery, Li-ion, NCA, rechargeable, prismatic | kg | N |
| battery production, NMC811, Li-ion, rechargeable, prismatic | CN; GLO | 2017-2020 | battery, Li-ion, NMC811, rechargeable, prismatic | kg | N |
| battery separator production | CN; GLO | 2009-2010 | battery separator | kg | U |
| cathode production, NCA, for Li-ion battery | CN; GLO | 2017-2020 | cathode, NCA, for Li-ion battery | kg | N |
| cathode production, NMC111, for Li-ion battery | CN; GLO | 2017-2020 | cathode, NMC111, for Li-ion battery | kg | N |
| cathode production, NMC811, for Li-ion battery | CN; GLO | 2017-2020 | cathode, NMC811, for Li-ion battery | kg | N |
| cobalt sulfate production | CN; GLO | 2018-2020 | cobalt sulfate | kg | N |
| copper collector foil production, for Li-ion battery | GLO | 2010-2020 | copper collector foil, for Li-ion battery | kg | N |
| disodium disulphite production | GLO | 2020-2020 | disodium disulphite | kg | N |
| electrolyte production, for Li-ion battery | GLO | 2019-2020 | electrolyte, for Li-ion battery | kg | N |
| high voltage system production, for Li-ion battery | GLO | 2014-2020 | high voltage system, for Li-ion battery | kg | N |
| integrated battery interface system production, for Li-ion battery | GLO | 2014-2020 | integrated battery interface system, for Li-ion battery | kg | N |
| low voltage system production, for Li-ion battery | GLO | 2014-2020 | low voltage system, for Li-ion battery | kg | N |
| synthetic graphite production, battery grade | CN; GLO | 2015-2020 | synthetic graphite, battery grade | kg | N |
| vinyl carbonate production | GLO | 2020-2020 | vinyl carbonate | kg | N |

## 6.2 Rechargeable lead acid battery

In addition to the Li-ion batteries, a new dataset on a valve regulated, stationary, rechargeable lead acid battery (VRLA, Table 17) is included in the new version v3.8. The inventory is based on a specific battery model produced in the USA. The data was collected and entered by the University of Pforzheim (Germany).

***Table 17. New dataset on rechargeable lead acid battery.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| battery production, lead acid, rechargeable, stationary | GLO; US | 2009-2010 | battery, lead acid, rechargeable, stationary | kg |

# 7 Building and construction materials

## 7.1 Concrete production

Concrete production is well represented geographically in the ecoinvent database. In v3.8, four new concrete production datasets for Austria have been added (Table 18). These datasets represent different concrete mixes, of different strength and exposure class. In addition, two new markets for concrete for Austria have been created.

***Table 18. New activities related to concrete production in Austria.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity Name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| concrete production, 25MPa, ready-mix, exposure class XC1 | AT; GLO | 2015-2021 | concrete, 25MPa | m3 |
| concrete production, 25MPa, ready-mix, exposure class XC2 | AT; GLO | 2015-2021 | concrete, 25MPa | m3 |
| concrete production, 30MPa, ready-mix, exposure class XC3 | AT; GLO | 2015-2021 | concrete, 30MPa | m3 |
| concrete production, 30MPa, ready-mix, exposure classes XC3/XD2/XF1/XA1 | AT; GLO | 2015-2021 | concrete, 30MPa | m3 |
| market for concrete, 25MPa | AT | 2015-2021 | concrete, 25MPa | m3 |
| market for concrete, 30MPa | AT | 2015-2021 | concrete, 30MPa | m3 |

## 7.2 Other updates

Both markets for supplementary cementitious materials (European and Global) have been corrected, and all transport removed, as it was being double counted. Those are generic markets; the transport is already accounted in the niche markets of the upstream value chain.

# 8 Chemicals

## 8.1 Polyurethane

The dataset for “polyurethane production, flexible foam” is replaced by three polyurethane datasets based on data provided by the European Association of Flexible Polyurethane Foam Blocks Manufacturers (EUROPUR). The new data covers methylene diphenyl diisocyanate (MDI) based polyurethane and toluene diisocyanate (TDI) based polyurethanes (high and low density). The reference product for all the new activities is still “polyurethane, flexible foam”. A new dataset and its corresponding market provide information about polyurethane (TDI based) as a flame retardant.

***Table 19. List of all new and updated activities related to polyurethane.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column. In the column v3.8, “N” stands for “New Activity” and “U” stands for “Updated Activity”.*

| Activity Name in v3.7.1 | Activity Name in v3.8 | Geography | Time Period | v3.8 |
|---|---|---|---|---|
| polyurethane production, flexible foam | polyurethane production, flexible foam, MDI-based | GLO; RER | 1997-2020 | U |
| | polyurethane production, flexible foam, TDI-based, high density | GLO; RER | 1997-2020 | U |
| | polyurethane production, flexible foam, TDI-based, low density | GLO; RER | 1997-2020 | U |
| | polyurethane production, flexible foam, TDI-based, flame retardant | GLO; RER | 1997-2020 | N |
| | market for polyurethane, flexible foam, flame retardant | GLO | 1997-2020 | N |

## 8.2 Chemical Factory Update

Due to an inconsistency with the unit of the dataset “chemical factory construction”, this input had to be replaced with “chemical factory construction, organics” in twelve datasets mentioned below. The exchange amount was recalculated by dividing the existing amount by the “chemical factory” input in the “chemical factory construction, organics” (1.26E7 kg).

***Table 20. List of all activities which were affected by the update of the dataset “chemical factory construction, organics”.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column.*

| Activity Name in v3.8 | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| indium tin oxide powder production, nanoscale, for sputtering target | GLO; RER | 2000-2005 | indium tin oxide powder, nanoscale, for sputtering target | kg |
| melamine urea formaldehyde adhesive production | GLO | 2010-2010 | melamine urea formaldehyde adhesive | kg |
| mineral supplement production, for beef cattle | GLO | 2019-2019 | mineral supplement, for beef cattle | kg |
| polyurethane adhesive production | GLO | 2015-2015 | polyurethane adhesive | kg |
| rutile production, synthetic, 95% titanium dioxide, Becher process | GLO | 2004-2004 | rutile, 95% titanium dioxide | kg |
| sodium chloride electrolysis | GLO; RER | 2010-2010 | sodium | kg |
| sputtering, indium tin oxide, for liquid crystal display | GLO; RER | 2005-2005 | sputtering, indium tin oxide, for liquid crystal display | m3 |
| treatment of waste x-ray film | GLO | 2011-2015 | waste x-ray film | kg |
| weaving of synthetic fibre, for industrial use | GLO | 2018-2019 | weaving, synthetic fibre | kg |

## 8.3 Phosphorus Oxychloride

The datasets “phosphoryl chloride production” and “phosphorus oxychloride production” were renamed to “phosphorus oxychloride production, from phosphorus trichloride” and “phosphorus oxychloride production, from phosphorus pentachloride” respectively, to avoid naming inconsistencies. See Table 1 and Table 2.

Due to this change, the “market for phosphoryl chloride” (GLO; RER) was deleted and a European “market for phosphorus oxychloride” was created. As a further consequence, the reference product in “phosphoryl chloride production” was renamed to “phosphorus oxychloride”, therefore the input of “phosphoryl chloride” in seven datasets mentioned in Table 21 had to be renamed to “phosphorus oxychloride”.

***Table 21. List of all activities which were affected by the update of the phosphorus oxychloride producing activities.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column. In the column v3.8, “N” stands for “New Activity”, “U” stands for “Updated Activity” and “D” stands for “Deleted Activity”.*

| Activity Name in v3.8 | Geography | Time Period | Product Name | Unit | v3.8 |
|---|---|---|---|---|---|
| photovoltaic cell production, multi-Si wafer | GLO; RER | 2004-2005 | photovoltaic cell, multi-Si wafer | m2 | U |
| photovoltaic cell production, ribbon-Si | GLO; RER | 2011-2011 | photovoltaic cell, ribbon-Si | m2 | U |
| photovoltaic cell production, single-Si wafer | GLO; RER | 2004-2005 | photovoltaic cell, single-Si wafer | m2 | U |
| triphenyl phosphate production | GLO | 2015-2020 | triphenyl phosphate | kg | U |
| market for phosphoryl chloride | GLO; RER | 2011-2011 | phosphoryl chloride | kg | D |
| market for phosphorus oxychloride | RER | 2015-2020 | phosphorus oxychloride | kg | N |

## 8.4 Styrene

The dataset “styrene production” was updated with the support from PlasticsEurope. A company survey of three producers and four sites was conducted, as a consequence the benzene emissions to water were removed from the dataset and the benzene emissions to air reduced by four orders of magnitude. This update had a significant impact on selected human toxicity indicators (e.g. ecological scarcity 2013, carcinogenic substances into air-total). The other key contribution to human toxicity impact categories, e.g. in ReCiPe Midpoint (H) – human toxicity, is the material input of benzene. The market for benzene in the ecoinvent database represents a mix of benzene produced through catalytic reforming and pyrolysis gasoline as well as a share produced as a by-product of coking. The latter technology has significant human toxicity impact scores. The shares of technologies contributing to the Global “market for benzene” where reviewed and the production volume for Global benzene production was revisited to provide a more accurate depiction of the supply. The technologies contributing to the benzene consumption of European styrene producers will be reviewed in the following releases.

***Table 22. List of all updated activities related to styrene.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column.*

| Activity Name in v3.8 | Geography in v3.8 | Time Period | Product Name | Unit |
|---|---|---|---|---|
| styrene production | GLO; RER | 2015-2020 | styrene | kg |
| benzene production | GLO | 1999-2002 | benzene | kg |

## 8.5 Other Updates

Several activities have been updated to improve the technology depiction in the dataset, or to gain in accuracy of the supply chain (link to specific suppliers). All concerned datasets are listed below.

In the datasets “natural gas production” for the GLO and CA-AB geography the by-product of butane is split into isobutane and butane, since isobutane is newly introduced to the database.

The dataset “natural gas liquids fractionation” combines four datasets from version 3.7.1 into one to ensure consistency. See Table 1 for details.

***Table 23. Updated activities related to the chemical sector with minor changes.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column. In the column v3.8, “N” stands for “New Activity”, “U” stands for “Updated Activity”, “AL” stand for adding of an activity link and “U*” marks that the activity has also been renamed.*

| Activity Name in v3.8 | Geography | Time Period | Product Name | Unit | v3.8 |
|---|---|---|---|---|---|
| 2,4-di-tert-butylphenol production | GLO | 2015-2020 | 2,4-di-tert-butylphenol | kg | U |
| barium carbonate production | GLO | 2015-2020 | barium carbonate | kg | U |
| barium sulfide production | GLO | 2015-2020 | barium sulfide | kg | U |
| bisphenol A production, powder | GLO; RER | 2000-2020 | bisphenol A, powder | kg | U |
| calcium carbonate production, precipitated | GLO; RER | 2015-2020 | calcium carbonate, precipitated | kg | U |
| chichibabin amination | GLO; RER | 2010-2010 | aminopyridine | kg | U |
| ethoxylated alcohol (AE3) production, petrochemical | GLO | 1992-1995 | ethoxylated alcohol (AE3) | kg | AL |
| market for carbon dioxide, in chemical industry | GLO | 2011-2011 | carbon dioxide, in chemical industry | kg | AL |
| market for isobutane | GLO | 2008-2008 | isobutane | kg | N |
| natural gas production | CA-AB | 2010-2010 | natural gas, high pressure | m3 | U |
| natural gas production | DZ | 1989-2000 | natural gas, high pressure | m3 | U |
| natural gas production | GLO | 2001-2001 | natural gas, high pressure | m3 | U |
| natural gas liquids fractionation | GLO | 2008-2018 | butane; ethane; isobutane; pentane; propane | kg | U* |
| pentane production | GLO; RER | 2001-2001 | pentane | kg | U |

# 9 Electricity

## 9.1 Changes in geographies

### 9.1.1 Deletion of the region US-FRCC

The US NERC region "US-FRCC" ceased to exist in 2019. Hence, its electricity markets are removed from the ecoinvent database. The data for energy generation (EPA, 2021) is merged into the region "US-SERC".

***Table 24. Deleted activities due to the removal of the US-FRCC power grid geography.***

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| electricity production, hard coal | US-FRCC | 1980-2015 | electricity, high voltage | kWh |
| electricity production, hydro, pumped storage | US-FRCC | 1945-2015 | electricity, high voltage | kWh |
| electricity production, hydro, reservoir, non-alpine region | US-FRCC | 1945-2015 | electricity, high voltage | kWh |
| electricity production, hydro, run-of-river | US-FRCC | 1945-2015 | electricity, high voltage | kWh |
| electricity production, lignite | US-FRCC | 1980-2015 | electricity, high voltage | kWh |
| electricity production, natural gas, combined cycle power plant | US-FRCC | 2000-2015 | electricity, high voltage | kWh |
| electricity production, natural gas, conventional power plant | US-FRCC | 1990-2015 | electricity, high voltage | kWh |
| electricity production, nuclear, boiling water reactor | US-FRCC | 1990-2015 | electricity, high voltage | kWh |
| electricity production, nuclear, pressure water reactor | US-FRCC | 1990-2015 | electricity, high voltage | kWh |
| electricity production, oil | US-FRCC | 1980-2015 | electricity, high voltage | kWh |
| electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | US-FRCC | 2005-2015 | electricity, low voltage | kWh |
| electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted | US-FRCC | 2005-2015 | electricity, low voltage | kWh |
| electricity production, photovoltaic, 570kWp open ground installation, multi-Si | US-FRCC | 2008-2015 | electricity, low voltage | kWh |
| electricity production, solar thermal parabolic trough, 50 MW | US-FRCC | 2010-2020 | electricity, high voltage | kWh |
| electricity voltage transformation from high to medium voltage | US-FRCC | 2012-2012 | electricity, medium voltage | kWh |
| electricity voltage transformation from medium to low voltage | US-FRCC | 2012-2012 | electricity, low voltage | kWh |
| heat and power co-generation, biogas, gas engine | US-FRCC | 2007-2015 | electricity, high voltage | kWh |
| heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical | US-FRCC | 2000-2015 | heat, district or industrial, natural gas | MJ |
| heat and power co-generation, natural gas, conventional power plant, 100MW electrical | US-FRCC | 1990-2015 | heat, district or industrial, natural gas | MJ |
| heat and power co-generation, oil | US-FRCC | 1980-2015 | heat, district or industrial, other than natural gas | MJ |
| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | US-FRCC | 2010-2015 | heat, district or industrial, other than natural gas | MJ |
| market for electricity, high voltage | US-FRCC | 2014-2017 | electricity, high voltage | kWh |
| market for electricity, low voltage | US-FRCC | 2014-2017 | electricity, low voltage | kWh |
| market for electricity, medium voltage | US-FRCC | 2014-2017 | electricity, medium voltage | kWh |

### 9.1.2 Renaming and establishing the electricity market for the region PR

Puerto Rico (initially abbreviated with "PR" in ecoinvent) became a US NERC region in 2019. Up to version 3.7.1 no electricity markets existed for this geography, thus new electricity market and voltage transformation datasets have been added for v3.8. The electricity generation data is sourced from eGRID2019 (EPA, 2021) (as for the other US NERC regions). For consistency with other US electricity markets the geography was renamed to “US-PR”.

***Table 25. Newly added electricity activities for US-PR.***

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| electricity voltage transformation from high to medium voltage | US-PR | 2021-2021 | electricity, medium voltage | kWh |
| electricity voltage transformation from medium to low voltage | US-PR | 2021-2021 | electricity, low voltage | kWh |
| market for electricity, high voltage | US-PR | 2021-2021 | electricity, high voltage | kWh |
| market for electricity, low voltage | US-PR | 2021-2021 | electricity, low voltage | kWh |
| market for electricity, medium voltage | US-PR | 2021-2021 | electricity, medium voltage | kWh |

## 9.2 Attributional electricity market updates

The production volumes, trade volumes and loss volumes of electricity supply in the attributional system models, cut-off and APOS, were updated to represent the 2018 electricity mixes, based on primary data from ENTSO-E and the International Energy Agency (IEA). Canadian and US power grids were updated to represent the year 2019 due the availability of more recent data. Not included in this update are the electricity mixes in Brazil, India and China, these represent the year 2012 (India and China) and 2014 (Brazil) respectively. Since electricity supply in these geographies is regionalized to the level of regional electricity grids, statistical data are not readily available in IEA or national databases.

The Rest of the World (RoW) markets for electricity are no longer generated in the attributional system models. 100% of statistically available global electricity supply is covered with specific mixes; no data is available for the remaining geographies, mostly small countries and island states.

The following sections describe the changes performed for the update of the electricity market mixes. Table 26 shows for which geographies the electricity market mixes were updated or added in the attributional system models.

***Table 26. Updated market mixes for electricity in the attributional system models.*** *If several geographies of the same activity with the same time period and system model exist, all of them are listed in the "Geography" column.*

| System model | Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|---|
| Allocation, cut-off; Allocation, APOS | market for electricity, high voltage | AE; AL; AM; AO; AR; AT; AU; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; CA-AB; CA-BC; CA-MB; CA-NB; CA-NF; CA-NS; CA-NT; CA-NU; CA-ON; CA-PE; CA-QC; CA-SK; CA-YK; CD; CG; CI; CL; CM; CO; CR; CU; CW; CY; CZ; DE; DK; DO; DZ; EC; EE; EG; ER; ES; ET; FI; FR; GA; GB; GE; GH; GI; GLO; GR; GT; HK; HN; HR; HT; HU; ID; IE; IL; IQ; IR; IS; IT; JM; JO; JP; KE; KG; KH; KP; KR; KW; KZ; LB; LK; LT; LU; LV; LY; MA; MD; ME; MK; MM; MN; MT; MU; MX; MY; MZ; NA; NE; NG; NI; NL; NO; NP; NZ; OM; PA; PE; PH; PK; PL; PT; PY; QA; RO; RS; RU; SA; SD; SE; SG; SI; SK; SN; SS; SV; SY; TG; TH; TJ; TM; TN; TR; TT; TW; TZ; UA; US-ASCC; US-PR; US-HICC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC; UY; UZ; VE; VN; XK; YE; ZA; ZM; ZW | 2014-2017 | electricity, high voltage | kWh |
| Allocation, cut-off; Allocation, APOS | market for electricity, medium voltage | AE; AL; AM; AO; AR; AT; AU; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; CA-AB; CA-BC; CA-MB; CA-NB; CA-NF; CA-NS; CA-NT; CA-NU; CA-ON; CA-PE; CA-QC; CA-SK; CA-YK; CD; CG; CI; CL; CM; CO; CR; CU; CW; CY; CZ; DE; DK; DO; DZ; EC; EE; EG; ER; ES; ET; FI; FR; GA; GB; GE; GH; GI; GLO; GR; GT; HK; HN; HR; HT; HU; ID; IE; IL; IQ; IR; IS; IT; JM; JO; JP; KE; KG; KH; KP; KR; KW; KZ; LB; LK; LT; LU; LV; LY; MA; MD; ME; MK; MM; MN; MT; MU; MX; MY; MZ; NA; NE; NG; NI; NL; NO; NP; NZ; OM; PA; PE; PH; PK; PL; PT; PY; QA; RO; RS; RU; SA; SD; SE; SG; SI; SK; SN; SS; | 2014-2017 | electricity, medium voltage | kWh |
| Allocation, cut-off; Allocation, APOS | market for electricity, low voltage | AE; AL; AM; AO; AR; AT; AU; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; CA-AB; CA-BC; CA-MB; CA-NB; CA-NF; CA-NS; CA-NT; CA-NU; CA-ON; CA-PE; CA-QC; CA-SK; CA-YK; CD; CG; CI; CL; CM; CO; CR; CU; CW; CY; CZ; DE; DK; DO; DZ; EC; EE; EG; ER; ES; ET; FI; FR; GA; GB; GE; GH; GI; GLO; GR; GT; HK; HN; HR; HT; HU; ID; IE; IL; IQ; IR; IS; IT; JM; JO; JP; KE; KG; KH; KP; KR; KW; KZ; LB; LK; LT; LU; LV; LY; MA; MD; ME; MK; MM; MN; MT; MU; MX; MY; MZ; NA; NE; NG; NI; NL; NO; NP; NZ; OM; PA; PE; PH; PK; PL; PT; PY; QA; RO; RS; RU; SA; SD; SE; SG; SI; SK; SN; SS; SV; SY; TG; TH; TJ; TM; TN; TR; TT; TW; TZ; UA; US-ASCC; US-PR; US-HICC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC; UY; UZ; VE; VN; XK; YE; ZA; ZM; ZW | 2014-2017 | electricity, low voltage | kWh |

### 9.2.1 Changes to production, trade and loss volume

A visual overview of these data sources applied for the update of electricity market mixes from ecoinvent v3.7.1 to v3.8 is presented in Figure 6. Data sources were applied as described in the following list:

- National production volumes for OECD and non-OECD countries: IEA extended World Energy Balances (IEA, 2020), for pumped hydro power IEA World Energy Statistics (IEA, 2020a)
- US grid region production volumes: eGrid (EIA, 2021)
- CA grid region production volumes: StatCAN (2021a-c)
- OECD electricity imports/ exports with OECD and non-OECD countries: OECD electricity imports/ exports (IEA, 2019a-b)
- European electricity imports/ exports: ENTSO-E (2021)
- National transmission and transformation losses: IEA extended World Energy Balances (IEA, 2019)
- Technology split factors: previous ecoinvent version (v3.7.1)

- Loss split factors: same as previous ecoinvent versions (based on Itten et al., 2014)
- Voltage level split factors: previous ecoinvent version (v3.6) (based on Itten et al., 2014)
- Canada internal electricity trade split factors: data provided by (Tirado, 2019)

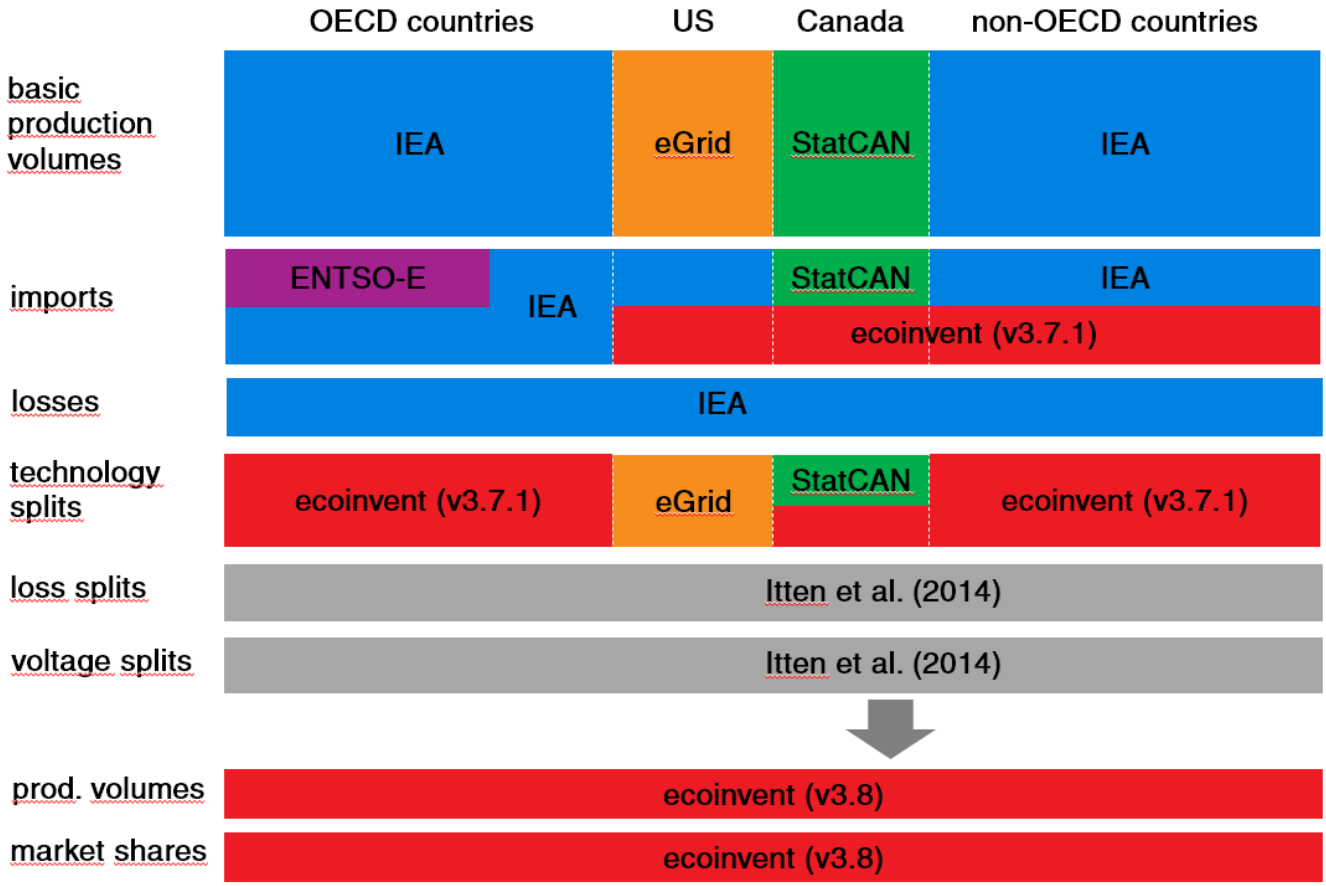


***Figure 6. Visual overview of main data sources used for updating electricity markets from ecoinvent v3.7.1 to v3.8.*** *Does not apply to the electricity markets of China, India (not updated)*

### 9.2.2 New import and technology splits

Some electricity import origins were added because the respective imports were not included in previous versions of ecoinvent. All the new splits are listed in Table 27 below. Temporal inconsistencies may occur due to limited data availability. Usually, imports are based on the data from the primary data sources of ENTSO-E and International Energy Agency (IEA). The splits in Table 27 are only used when this information was not available. The resulting generated new import datasets are listed in section 9.2.3, Table 29.

***Table 27. New import splits for updated electricity markets.*** *Columns "Data year" and "Data source" represent the year in which the data on technology splits is valid for and the according source respectively.*

| Importing region | Import splits | Data year | Data source |
|---|---|---|---|
| BA | 59.156% electricity, high voltage, import from HR<br>2.875% electricity, high voltage, import from CZ*<br>11.998% electricity, high voltage, import from IT*<br>13.838% electricity, high voltage, import from ME<br>12.133% electricity, high voltage, import from RS | 2018 | United Nations (2021) |
| BD | 100% electricity, high voltage, import from IN-Eastern grid* (based on interconnector location) | 2018 | MR Chauhan and VS Bal (2011), Enerdata (2014) |
| HR | 0.001% electricity, high voltage, import from BG*<br>6.06% electricity, high voltage, import from BA<br>52.694% electricity, high voltage, import from HU<br>0.843% electricity, high voltage, import from RS<br>40.402% electricity, high voltage, import from SI | 2018 | United Nations (2021) |
| RU | 5.105% electricity, high voltage, import from AZ*<br>0.005% electricity, high voltage, import from FI*<br>1.792% electricity, high voltage, import from GE*<br>88.45% electricity, high voltage, import from KZ*<br>2.925% electricity, high voltage, import from LT<br>0.186% electricity, high voltage, import from LV<br>1.5% electricity, high voltage, import from MN*<br>0.003% electricity, high voltage, import from NO*<br>0.034% electricity, high voltage, import from UZ* | 2018 | United Nations (2021) |

Some technology splits for electricity generation technologies had to be added because they were not included in the previous ecoinvent versions. These splits are listed in the table below. Temporal inconsistencies may occur due to limited data availability.

***Table 28. New technology splits for updated electricity markets.*** *The activities listed in the "Technology splits" column represent the production means with which the countries of column "Geography" produce electricity from the fuel in column "Fuel type". Columns "Data year" and "Data source" represent the year in which the data on technology splits is valid for and the according source respectively.*

| Regions | Fuel type | Data year | Data year | Data source |
|---|---|---|---|---|
| IL | natural gas (CHP) | 81.085% heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical<br>18.915% heat and power co-generation, natural gas, conventional power plant, 100MW electrical<br>(based on the capacities of the plants as proxy; combined cycle: Ashdod Energy, Dead Sea Works, IPP Delek Soreq, Ramat Negev Energy, conventional: Ashdod Refinery, Hadera AIPM; gas turbines without combined cycle are approximated with conventional plants due the similar efficiency and a lack of a better dataset in ecoinvent) | 2018 | S&P Global (2021) |
| PA | natural gas (non-CHP) | 100% electricity production, natural gas, combined cycle power plant<br>(only one plant, AES Colon) | 2018 | S&P Global (2021) |
| TG | natural gas (non-CHP) | 100% electricity production, natural gas, conventional power plant<br>(only one plant, Lome Contour, which is a gas-based internal combustion engine plant that lacks an appropriate ecoinvent dataset and was thus approximated by conventional plant due to the similar efficiencies) | 2018 | S&P Global (2021) |
| US-PR | solar PV | 23.14% 3kWp slanted-roof installation, single-Si, panel, mounted, on roof<br>28.82% 3kWp slanted-roof installation, multi-Si, panel, mounted, on roof<br>48.03% 570kWp open ground installation, multi-Si, on open ground<br>(US average from previous ecoinvent version) | 2018 | Ecoinvent centre (2020) |
| US-ASCC | solar PV | 23.14% 3kWp slanted-roof installation, single-Si, panel, mounted, on roof<br>28.82% 3kWp slanted-roof installation, multi-Si, panel, mounted, on roof<br>48.03% 570kWp open ground installation, multi-Si, on open ground<br>(US average from previous ecoinvent version, replaces the GLO average from before) | 2018 | Ecoinvent centre (2020) |
| PR | wind (onshore) | 1.052% electricity production, wind, <1MW turbine, onshore<br>98.948% electricity production, wind, 1-3MW turbine, onshore<br>(based on capacities of the existing wind farms in the region as proxy, same approach for all other wind farms) | 2018 | The windpower (2021) |
| AE | wind (total) | 100% electricity production, wind, <1MW turbine, onshore | 2018 | The windpower (2021) |
| BA | wind (total) | 64.339% electricity production, wind, 1-3MW turbine, onshore<br>35.661% electricity production, wind, >3MW turbine, onshore | 2018 | The windpower (2021) |
| ER | wind (total) | 100% electricity production, wind, <1MW turbine, onshore | 2018 | The windpower (2021) |
| KW | wind (total) | 100% electricity production, wind, 1-3MW turbine, onshore | 2018 | The windpower (2021) |
| LB | wind (total) | 28.504% electricity production, wind, 1-3MW turbine, onshore | 2021 | S&P Global (2021) |

| Regions | Fuel type | Data year | Data year | Data source |
|---|---|---|---|---|
| | | 71.496% electricity production, wind, >3MW turbine, onshore | | |
| NA | wind (total) | 4.215% electricity production, wind, <1MW turbine, onshore<br>95.785% electricity production, wind, 1-3MW turbine, onshore | 2018 | The windpower (2021) |

### 9.2.3 New import datasets

With the update of electricity data, especially trade volumes, certain new import datasets had to be created to represent the trade of electricity mentioned in the statistics. Table 29 lists all newly created import datasets with their respective origin and destination.

***Table 29. New import activities for electricity.***

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| electricity, high voltage, import from AZ | RU | 2021-2021 | electricity, high voltage | kWh |
| electricity, high voltage, import from BG | HR | 2021-2021 | electricity, high voltage | kWh |
| electricity, high voltage, import from GB | BE | 2021-2021 | electricity, high voltage | kWh |
| electricity, high voltage, import from GE | RU | 2021-2021 | electricity, high voltage | kWh |
| electricity, high voltage, import from IN-Eastern grid | BD | 2021-2021 | electricity, high voltage | kWh |
| electricity, high voltage, import from KZ | RU | 2021-2021 | electricity, high voltage | kWh |
| electricity, high voltage, import from MN | RU | 2021-2021 | electricity, high voltage | kWh |
| electricity, high voltage, import from NO | RU | 2021-2021 | electricity, high voltage | kWh |
| electricity, high voltage, import from UZ | RU | 2021-2021 | electricity, high voltage | kWh |

### 9.2.4 Update of transformation losses

The amount of electricity losses present in all transformation datasets named “electricity voltage transformation from high to medium voltage” and “electricity voltage transformation from medium to low voltage” listed in Table 30 are updated. The losses are valid for the year 2018, based on IEA (2021) electricity generation and trade statistics.

***Table 30. Updated electricity transformation datasets.*** *If several geographies of the same activity with the same time period and system model exist, all of them are listed in the "Geography" column.*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| electricity voltage transformation from high to medium voltage | AE; AL; AM; AO; AT; AR; AU; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; CA-AB; CA-BC; CA-MB; CA-NB; CA-NF; CA-NS; CA-NT; CA-NU; CA-ON; CA-PE; CA-SK; CA-QC; CA-YK; CD; CG; CI; CL; CM; CO; CR; CU; CW; CY; CZ; DE; DK; DO; DZ; EC; EE; EG; ER; ES; ET; FI; FR; GA; GB; GE; GH; GI; GR; GT; HK; HN; HR; HT; HU; ID; IE; IL; IQ; IR; IS; IT; JM; JO; JP; KE; KG; KH; KP; KR; KW; KZ; LB; LK; LT; LU; LV; LY; MA; MD; ME; MK; MM; MN; MT; MU; MX; MY; MZ; NA; NE; NG; NI; NL; NO; NP; NZ; OM; PA; PE; PH; PK; PL; PT; PY; QA; RO; RS; RU; SA; SD; SE; SG; SI; SK; SN; SS; SV; SY; TG; TH; TJ; TM; TN; TR; TT; TW; TZ; UA; US-ASCC; US-HICC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC; UY; UZ; VE; VN; XK; YE; ZA; ZM; ZW | 2012-2012 | electricity, medium voltage | kWh |
| electricity voltage transformation from medium to low voltage | AE; AL; AM; AO; AT; AU; AR; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; CA-AB; CA-BC; CA-MB; CA-NB; CA-NF; CA-NS; CA-NT; CA-NU; CA-ON; CA-PE; CA-SK; CA-QC; CA-YK; CD; CG; CI; CL; CM; CO; CR; CU; CW; CY; CZ; DE; DK; DO; DZ; EC; EE; EG; ER; ES; ET; FI; FR; GA; GB; GE; GH; GI; GR; GT; HK; HN; HR; HT; HU; ID; IE; IL; IQ; IR; IS; IT; JM; JO; JP; KE; KG; KH; KP; KR; KW; KZ; LB; LK; LT; LU; LV; LY; MA; MD; ME; MK; MM; MN; MT; MU; MX; MY; MZ; NA; NE; NG; NI; NL; NO; NP; NZ; OM; PA; PE; PH; PK; PL; PT; PY; QA; RO; RS; RU; SA; SD; SE; SG; SI; SK; SN; SS; SV; SY; TG; TH; TJ; TM; TN; TR; TT; TW; TZ; UA; US-ASCC; US-HICC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC; UY; UZ; VE; VN; XK; YE; ZA; ZM; ZW | 2012-2012 | electricity, low voltage | kWh |

### 9.2.5 Swiss electricity markets update for attribution

Most countries in ecoinvent are modelled based on electricity production statistics (domestic production) plus electricity imports from neighbouring countries. The production mix models domestic electricity production only. For Switzerland, the Swiss electricity supply mix based on guarantees of origin is modelled. As such, the Swiss electricity market is fully based on virtual trade and shall not be mixed up with any physical production in Switzerland. The production mix models physical domestic electricity production.

For v3.8 the production mix, supply mix and previously named "label-certified" mix have been updated. The "label-certified" electricity markets and accompanying datasets were renamed to "renewable energy products" (see Table 1 and Table 2 for details). Updated markets and production mixes are listed in Table 31. The datasets were updated to represent the year 2019. The following data sources were used to calculate the swiss electricity mixes:

- Pronovo (2019). Stromkennzeichnung 2019. https://www.strom.ch/de/service/stromkennzeichnung
- BFE. (2020). Schweizerische Gesamtenergiestatistik 2020. Bundesamt für Energie (BFE).
- BFE (2019). Schweizerische Elektrizitätsstatistik 2019. Bundesamt für Energie (BFE).
- BFE (2019a). Thermische Stromproduktion inklusive Wärmekraftkopplung (WKK) in der Schweiz (Ausgabe 2019). Teilstatistik. Energiestatistik. Bundesamt für Energie (BFE).
- BFE (2020a). Schweizerische Statistik der erneuerbaren Energien, Ausgabe 2020 – Datentabellen. Teilstatistik. Energiestatistik. Bundesamt für Energie (BFE).

- BFE (2021). Statistik der Wasserkraftanlagen der Schweiz. Stand 1.1.2021. Teilstatistik. Energiestatistik. Bundesamt für Energie (BFE).
- Wind-data (2021). Die Website für Windenergie-Daten der Schweiz. https://wind-data.ch/wka/
- Swiss Small Hydro (2020). Factsheet Kleinwasserkraft. Swiss Small Hydro. Schweizer Verband der Kleinwasserkraft
- VUE (2020). Jahresbericht 2019. Verein für umweltgerechte Energie (VUE).
- VUE (2021). Der Markt für erneuerbare Energieprodukte 2019. Verein für umweltgerechte Energie (VUE).


***Table 31. Updated swiss electricity markets.*** *Former "label-certified" markets were renamed to "renewable energy products".*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| market for electricity, high voltage | CH | 2014-2017 | electricity, high voltage | kWh |
| market for electricity, medium voltage | CH | 2014-2017 | electricity, medium voltage | kWh |
| market for electricity, low voltage | CH | 2014-2017 | electricity, low voltage | kWh |
| market for electricity, high voltage, renewable energy products | CH | 2011-2015 | electricity, high voltage, renewable energy products | kWh |
| market for electricity, medium voltage, renewable energy products | CH | 2011-2015 | electricity, medium voltage, renewable energy products | kWh |
| market for electricity, low voltage, renewable energy products | CH | 2011-2015 | electricity, low voltage, renewable energy products | kWh |
| electricity, high voltage, production mix | CH | 2021-2021 | electricity, high voltage | kWh |
| electricity, high voltage, renewable energy products, production mix | CH | 2021-2021 | electricity, high voltage, renewable energy products | kWh |

## 9.3 Energy storage

The v3.8 includes two new technologies of energy storage: compressed air energy storage (CAES) and adiabatic compressed air energy storage (ACAES).

### 9.3.1 Compressed air energy storage

The compressed air energy storage system is an energy storage system that uses electricity to compress air and store it in underground caverns or porous rock formation. The air is released when needed and passed through a turbine to generate electricity. In v3.8, the datasets in Table 32 have been added for compressed air energy storage.

***Table 32. New activities related to compressed air energy storage.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity Name | Geography | Time period | Product Name | Unit |
|---|---|---|---|---|
| compressed air energy storage plant construction, 200 MW electrical | RER; GLO | 2015-2021 | compressed air energy storage plant, 200 MW electrical | unit |
| gas turbine construction, 80MW electrical, for compressed air energy storage | GLO | 2011-2021 | gas turbine, 80MW, for compressed air energy storage | unit |
| market for compressed air energy storage plant, 200 MW electrical | GLO | 2015-2021 | compressed air energy storage plant, 200 MW electrical | unit |
| market for gas turbine, 80MW, for compressed air energy storage | GLO | 2015-2021 | gas turbine, 80MW, for compressed air energy storage | unit |
| electricity production, compressed air energy storage | RER; GLO | 1998-2021 | electricity, high voltage | kWh |

### 9.3.2 Adiabatic compressed air energy storage

The compressed air energy storage system is an energy storage system that uses electricity to compress air and store it in underground caverns or porous rock formation. The air is released when needed and passed through a turbine to generate electricity. The difference to the compressed air energy storage system is in the technology used to heat the outflow of air from the storage facility. In v3.8, the datasets in Table 33 have been added for adiabatic compressed air energy storage.

***Table 33. New activities related to adiabatic compressed air energy storage.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity Name | Geography | Time period | Product Name | Unit |
|---|---|---|---|---|
| compressed air energy storage plant construction, adiabatic, 150 MW electrical | RER; GLO | 2015-2021 | compressed air energy storage plant, adiabatic, 150 MW electrical | unit |
| thermal energy storage construction, for adiabatic compressed air energy storage | GLO | 2015-2021 | thermal energy storage, for adiabatic compressed air energy storage | unit |
| market for compressed air energy storage plant, adiabatic, 150 MW electrical | GLO | 2015-2021 | compressed air energy storage plant, adiabatic, 150 MW electrical | unit |
| market for thermal energy storage, for adiabatic compressed air energy storage | GLO | 2015-2021 | thermal energy storage, for adiabatic compressed air energy storage | unit |
| electricity production, compressed air energy storage, adiabatic | RER; GLO | 1998-2021 | electricity, high voltage | kWh |

# 10 Electronics

## 10.1 Electronic devices

Two new datasets representing smartphone and tablet based on available literature data were created for v3.8. Additionally, a new dataset on a liquid crystal display, a printed wiring board, and earpiece and speaker for mobile devices were added in the process. Two new treatment activities were created for the devices following the same modelling approach as the dataset “treatment of used laptop”. The new datasets are listed in Table 34.

The laptop production dataset was completely remodelled following newer available literature data. The accompanying treatment datasets were updated to reflect the change in material composition of the laptop.

***Table 34. New and updated electronic devices and accompanying treatment datasets.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column. In the column v3.8, “N” stands for “New Activity”, “U” stands for “Updated Activity” and “D” stands for “Deleted Activity”.*

| Activity name | Geography | Time Period | Product Name | Unit | v3.8 |
|---|---|---|---|---|---|
| computer production, laptop | GLO | 2011-2024 | computer, laptop | unit | U |
| consumer electronics production, mobile device, smartphone | GLO | 2014-2020 | consumer electronics, mobile device, smartphone | unit | N |
| consumer electronics production, mobile device, tablet | GLO | 2014-2020 | consumer electronics, mobile device, tablet | unit | N |
| electronic component production, passive, mobile, earpiece and speaker | GLO | 2014-2020 | electronic component, passive, mobile, earpiece and speaker | kg | N |
| liquid crystal display production, unmounted, mobile device | GLO | 2014-2020 | liquid crystal display, unmounted, mobile device | kg | N |
| printed wiring board production, mounted mainboard, mobile device, double-sided, Pb free | GLO | 2014-2020 | printed wiring board, mounted mainboard, mobile device, double-sided, Pb free | m2 | N |
| treatment of used laptop computer, manual dismantling | CH; GLO | 2005-2005 | used laptop computer | kg | U |
| treatment of used laptop computer, mechanical treatment | GLO | 2005-2005 | used laptop computer | kg | U |
| treatment of used smartphone, mechanical treatment | GLO | 2020-2020 | used smartphone | kg | N |
| treatment of used tablet, mechanical treatment | GLO | 2020-2020 | used tablet | kg | N |

## 10.2 Electronics components

Electronics components have been adjusted to allow a more accurate modelling of the final devices. For example, the amount of infrastructure in the basic electronic components production auxiliaries datasets has been adjusted from 2e-8 to 1e-12 based on expert assessment. Targeted updates were performed for the rest of the datasets (ie. the input of silver was removed from “capacitor production, film type, for through-hole mounting”; the amount of silver was replaced by aluminium in “inductor production, low value multilayer chip” and the input of gold was removed from “resistor production, surface-mounted”). Additional corrections were also performed (ie. for “integrated circuit production, memory type” the amount 'wafer, fabricated, for integrated circuit' was not scaled to the amount of the reference product but for 2.33g of a single chip; in the “printed wiring board production, for surface mounting” datasets some exchanges had to be divided by a factor of 3.684 as in the initial data collection an average was used from three European produces, however the division was not performed; in the “router, internet” dataset the amount of the printed wiring board input was entered in m2 and was corrected to kg with a conversion factor of 4.31 kg/m2).

***Table 35. Updated datasets related to electronic components.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| capacitor production, auxilliaries and energy use | GLO | 1998-2005 | capacitor, auxilliaries and energy use | kg |
| diode production, auxilliaries and energy use | GLO | 1998-2007 | diode, auxilliaries and energy use | kg |
| inductor production, auxilliaries and energy use | GLO | 1998-2005 | inductor, auxilliaries and energy use | kg |
| resistor production, auxilliaries and energy use | GLO | 1998-2005 | resistor, auxilliaries and energy use | kg |
| transistor production, auxilliaries and energy use | GLO | 1998-2005 | transistor, auxilliaries and energy use | kg |
| capacitor production, film type, for through-hole mounting | GLO | 1994-2007 | capacitor, film type, for through-hole mounting | kg |
| inductor production, low value multilayer chip | GLO | 2005-2007 | inductor, low value multilayer chip | kg |
| resistor production, surface-mounted | GLO | 1994-2007 | resistor, surface-mounted | kg |
| integrated circuit production, memory type | GLO | 2000-2006 | integrated circuit, memory type | kg |
| printed wiring board production, for surface mounting, Pb containing surface | GLO | 2003-2006 | printed wiring board, for surface mounting, Pb containing surface | m2 |
| printed wiring board production, for surface mounting, Pb free surface | GLO | 2003-2006 | printed wiring board, for surface mounting, Pb free surface | m2 |
| router, internet | CH; GLO | 2005-2009 | router, internet | unit |
| treatment of electronics scrap from control units | RER | 1990-2005 | electronics scrap from control units | kg |
| treatment of electronics scrap, metals recovery in copper smelter | GLO; SE | 2000-2005 | electronics scrap | kg |
| treatment of metal part of electronics scrap, in copper, anode, by electrolytic refining | GLO; SE | 2000-2005 | metal part of electronics scrap, in copper, anode | kg |
| treatment of precious metal from electronics scrap, in anode slime, precious metal extraction | GLO; SE | 2000-2005 | precious metal from electronics scrap, in anode slime | kg |
| treatment of spent sawing slurry from Si-wafer cutting | GLO; RER | 2005-2006 | spent sawing slurry from Si-wafer cutting | l |

# 11 Forestry and wood-based products

## 11.1 Bamboo supply chains

Activities related to bamboo forestry and the production of (intermediate) bamboo construction materials were added to the wood and forestry sector in v3.8 of the ecoinvent database. Datasets are available for the geographies of Brazil (BR), China (CN), Colombia (CO), and the Philippines (PH). These new datasets were developed by ETH (Dr. Zea Escamilla) with the support of the International Organization for Bamboo and Rattan INBAR.

The bamboo supply chain as represented in the ecoinvent database starts with the production of bamboo culms (i.e., the stems of bamboo) and ends with the production of woven bamboo mats. Drying and trimming of the bamboo culms yields the product bamboo pole. The poles are processed into flattened bamboo in a handcrafted process. For this purpose, bamboo poles are cracked open, the internodes are removed, and innermost part of the bamboo is trimmed down. Flattened bamboo can be used for the manufacturing woven bamboo mats for which flattened bamboo is divided into strips. The strips are peeled into veneers and then woven to form a mat. The production of woven bamboo mats is usually done manually and is typically performed in small, rural communities. Bamboo poles and woven bamboo mats are used as construction material, e.g., woven bamboo mats are usually used as lightweight walls and bamboo poles can be used for the construction of columns, beams, or struts.

***Table 36 New activities related bamboo products.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| bamboo forestry, sustainable forest management | BR; CN; CO; PH; GLO | 2010-2020 | bamboo culm | kg |
| bamboo pole production | BR; CN; CO; PH; GLO | 2010-2020 | bamboo pole | kg |
| flattened bamboo production | BR; CN; CO; PH; GLO | 2010-2020 | flattened bamboo | kg |
| woven bamboo mat production | BR; CN; CO; PH; GLO | 2010-2020 | woven bamboo mat | kg |
| market for bamboo culm | BR; CN; CO; PH; GLO | 2010-2020 | bamboo culm | kg |
| market for flattened bamboo | BR; CN; CO; PH; GLO | 2010-2020 | bamboo pole | kg |
| market for bamboo pole | BR; CN; CO; PH; GLO | 2010-2020 | flattened bamboo | kg |
| market for woven bamboo mat | BR; CN; CO; PH; GLO | 2010-2020 | woven bamboo mat | kg |

The sawing and trimming during the manufacturing of bamboo poles, flattened bamboo and woven bamboo mats leads to production of the by-product 'waste bamboo residues'. Waste bamboo residues are treated by open burning and thus the new treatment activity 'treatment of waste bamboo residues, open burning' was created for v3.8 of the database.

***Table 37 New activities related to the treatment of waste bamboo residues.***

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| treatment of waste bamboo residues, open burning | GLO | 2010-2020 | waste bamboo residues | kg |
| market for waste bamboo residues | GLO | 2010-2020 | waste bamboo residues | kg |

## 11.2 Other updates

Smaller updates and corrections have been done to other datasets in the sector. Those are listed in the table below.

***Table 38. Updated datasets in the sector.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity Name | Geography | Time Period | Product | Unit |
|---|---|---|---|---|
| fibreboard production, soft, from wet processes | CH | 2008-2009 | fibreboard, soft | m3 |
| fibreboard production, soft, from wet processes | GLO | 2007-2009 | fibreboard, soft | m3 |
| fibreboard production, soft, latex bonded | CH; GLO | 2008-2009 | fibreboard, soft, latex bonded | m3 |
| fibreboard production, soft, without adhesives | CH; GLO | 2008-2009 | fibreboard, soft, without adhesives | m3 |
| glued laminated timber production, average glue mix | CA-QC | 2009-2011 | glued laminated timber, average glue mix | m3 |
| market for sawnwood, board, softwood, dried (u=10%), planed | CH | 2019-2019 | sawnwood, board, softwood, dried (u=10%), planed | m3 |
| oriented strand board production | CA-QC | 2005-2006 | oriented strand board | m3 |
| sawing, hardwood | CA-QC; CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, hardwood, raw | m3 |
| sawing, softwood | CH; Europe without Switzerland; GLO | 2011-2013 | sawnwood, softwood, raw | m3 |
| softwood forestry, mixed species, boreal forest | CA-QC; GLO | 2006-2012 | sawlog and veneer log, softwood, measured as solid wood under bark | m3 |

# 12 Metals

## 12.1 Scarce and critical metals

The new and updated datasets were provided by the Swiss Federal Laboratories for Materials Science and Technology, EMPA (sponsored by the Swiss Federal Office for the Environment, BAFU) in the context of the update and expansion of the life cycle inventories for the primary production of scarce and critical metals.

In addition to that, other datasets within the same sectors were updated in order to harmonize the production volumes, to ensure that the market shares along the supply chain are consistent with the latest data available. Some new datasets related to titanium production and scandium oxide production were also introduced to ensure a correct modelling in the Consequential system model. All datasets introduced or updated for v3.8 in the context of this project are shown in Table 39.

***Table 39. New and updated activities related to the production of scarce and critical metals.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column. In column "v3.8", "U" stands for "Updated activity", "N" stands for "New activity" and "PV" indicates that the only quantitative change was an update to the production volume of the output(s). "N*" indicates that the new dataset is a recontextualized copy of the GLO dataset that existed in version 3.7.1.*

| Activity Name | Geography | Time Period | Product | Unit | v3.8 |
|---|---|---|---|---|---|
| barite production | CA-QC; GLO; RER | 1978-2007 | barite | kg | PV |
| beryllium production | GLO; US | 2013-2020 | beryllium | kg | N |
| chlorine, for reuse in titanium tetrachloride production, to generic market for chlorine | CN; GLO; JP | 2021-2021 | chlorine, liquid | kg | N |
| chromite ore concentrate production | GLO | 1994-2017 | chromite ore concentrate | kg | U |
| chromite ore concentrate production | KZ | 1994-2017 | chromite ore concentrate | kg | N |
| electrolysis of magnesium chloride, from titanium sponge production | CN; GLO; JP | 2020-2024 | magnesium chloride, from titanium sponge production | kg | N |
| ferrochromium production, high-carbon, 55% Cr | GLO; ZA | 2012-2016 | ferrochromium, high-carbon, 55% Cr | kg | PV |
| ferrochromium production, high-carbon, 68% Cr | GLO | 2017-2021 | ferrochromium, high-carbon, 68% Cr | kg | U |
| ferrochromium production, high-carbon, 68% Cr | KZ | 2017-2021 | ferrochromium, high-carbon, 68% Cr | kg | N |
| ferroniobium production, from pyrochlore concentrate, 66% Nb | BR; GLO | 2019-2023 | ferroniobium, 66% Nb | kg | N |
| fluorspar production, 97% purity | GLO | 1976-1991 | fluorspar, 97% purity | kg | PV |
| heavy mineral sand quarry operation | AU; GLO | 2015-2020 | zircon, 50% zirconium | kg | U |
| heavy mineral sand quarry operation and titania slag production | GLO; ZA | 2015-2015 | titania slag, 85% titanium dioxide | kg | PV |
| ilmenite - magnetite mine operation | GLO | 2000-2015 | ilmenite, 54% titanium dioxide | kg | PV |
| lithium carbonate production, from concentrated brine | GLO | 2009-2010 | lithium carbonate | kg | PV |
| lithium carbonate production, from spodumene | CN | 2014-2020 | lithium carbonate | kg | N |
| lithium carbonate production, from spodumene | GLO | 2014-2020 | lithium carbonate | kg | U |
| magnesium, for reuse in titanium sponge production, to generic market for magnesium | CN; GLO; JP | 2021-2021 | magnesium | kg | N |
| market for beryllium | GLO | 2013-2020 | beryllium | kg | N |
| market for chlorine, for reuse in titanium tetrachloride production | CN; GLO; JP | 2021-2021 | chlorine, for reuse in titanium tetrachloride production | kg | N |
| market for electrolyte, for solid oxide fuel cell | GLO | 2021-2021 | electrolyte, for solid oxide fuel cell | kg | N |

| Activity Name | Geography | Time Period | Product | Unit | v3.8 |
|---|---|---|---|---|---|
| market for ferrochromium, high-carbon, 68% Cr | GLO | 2011-2011 | ferrochromium, high-carbon, 68% Cr | kg | U |
| market for ferroniobium, 66% Nb | GLO | 2019-2023 | ferroniobium, 66% Nb | kg | N |
| market for magnesium chloride, from titanium sponge production | GLO | 2021-2021 | magnesium chloride, from titanium sponge production | kg | N |
| market for magnesium, for reuse in titanium sponge production | CN; GLO; JP | 2021-2021 | magnesium, for reuse in titanium sponge production | kg | N |
| market for oxalic acid | GLO | 2020-2024 | oxalic acid | kg | N |
| market for pyrochlore concentrate | GLO | 2019-2023 | pyrochlore concentrate | kg | N |
| market for rare earth tailings, from bastnaesite and monazite ore | GLO | 2020-2024 | rare earth tailings, from bastnaesite and monazite ore | kg | N |
| market for scandium oxide | GLO | 2020-2024 | scandium oxide | kg | N |
| market for spodumene | GLO | 2011-2014 | spodumene | kg | U |
| market for tantalum concentrate, 30% Ta2O5 | GLO | 2019-2023 | tantalum concentrate, 30% Ta2O5 | kg | N |
| market for titania slag, 94% titanium dioxide | GLO | 2018-2022 | titania slag, 94% titanium dioxide | kg | N |
| market for titanium sponge | GLO | 2020-2024 | titanium sponge | kg | N |
| niobium mine operation and beneficiation, from pyrochlore ore | BR; GLO | 2019-2023 | pyrochlore concentrate | kg | N |
| oxalic acid production | CN; GLO | 2020-2024 | oxalic acid | kg | N |
| rare earth element mine operation and beneficiation, bastnaesite and monazite ore | CN-NM; GLO | 2017-2018 | rare earth oxide concentrate, 50% REO | kg | U |
| rare earth element mine operation and beneficiation, bastnaesite ore | CN-SC; GLO | 2017-2018 | rare earth oxide concentrate, 70% REO | kg | U |
| rare earth oxides production, from rare earth oxide concentrate, 50% REO | CN-NM | 2017-2018 | cerium oxide;<br>lanthanum oxide;<br>neodymium oxide;<br>samarium-europium-gadolinium oxide | kg;<br>kg;<br>kg;<br>kg | U |
| rare earth oxides production, from rare earth oxide concentrate, 70% REO | CN-SC | 2017-2018 | cerium oxide;<br>europium oxide;<br>lanthanum oxide;<br>lanthanum-cerium oxide;<br>praseodymium-neodymium oxide;<br>samarium oxide;<br>yttrium oxide | kg;<br>kg;<br>kg;<br>kg;<br>kg;<br>kg;<br>kg | U |
| rare earth oxides production, from rare earth oxide concentrate, 70% REO | GLO | 2017-2018 | cerium oxide;<br>europium oxide;<br>lanthanum oxide;<br>lanthanum-cerium oxide;<br>praseodymium-neodymium oxide;<br>samarium oxide;<br>yttrium oxide | kg;<br>kg;<br>kg;<br>kg;<br>kg;<br>kg;<br>kg | PV |
| rutile production, synthetic, 95% titanium dioxide, Becher process | AU | 2004-2019 | rutile, 95% titanium dioxide | kg | N* |
| rutile production, synthetic, 95% titanium dioxide, Becher process | GLO | 2004-2019 | rutile, 95% titanium dioxide | kg | U |
| rutile production, synthetic, 95% titanium dioxide, Benelite process | GLO | 2000-2019 | rutile, 95% titanium dioxide | kg | PV |
| rutile production, synthetic, 95% titanium dioxide, Benelite process | IN | 2000-2019 | rutile, 95% titanium dioxide | kg | N* |
| scandium oxide production, from rare earth tailings | CN-NM; GLO | 2020-2024 | rare earth tailings, from bastnaesite and monazite ore | kg | N |
| scandium oxide to generic market for electrolyte, for solid oxide fuel cell | GLO | 2021-2021 | electrolyte, for solid oxide fuel cell | kg | N |
| spodumene production | AU | 2000-2012 | spodumene | kg | N |
| spodumene production | GLO | 2000-2012 | spodumene | kg | U |

| Activity Name | Geography | Time Period | Product | Unit | v3.8 |
|---|---|---|---|---|---|
| spodumene production | RER | 2000-2000 | spodumene | kg | D |
| strontium carbonate production | GLO | 2014-2021 | strontium carbonate | kg | U |
| strontium mine operation and beneficiation | CN; ES; GLO | 2014-2020 | strontium sulfate, 90% SrSO4 | kg | N |
| strontium sulfate quarry operation | GLO | 2012-2012 | strontium sulfate, unprocessed | kg | U |
| tantalum mine operation and beneficiation | CD; GLO; RW | 2019-2023 | tantalum concentrate, 30% Ta2O5 | kg | N |
| tantalum powder production, capacitor-grade | CN; GLO | 2019-2023 | tantalum powder, capacitor-grade | kg | N |
| tantalum production, powder, capacitor-grade | GLO | 2000-2003 | tantalum, powder, capacitor-grade | kg | U |
| titanium dioxide production, chloride process | GLO; RER | 2005-2019 | titanium dioxide | kg | PV |
| titanium dioxide production, sulfate process | GLO; RER | 2005-2019 | titanium dioxide | kg | PV |
| titanium production | GLO | 2004-2004 | titanium | kg | U |
| titanium production, triple-melt | GLO | 2004-2004 | titanium, triple-melt | kg | U |
| titanium sponge production, from titanium tetrachloride | CN; GLO; JP | 2020-2024 | titanium sponge | kg | N |
| titanium tetrachloride production | CN; JP | 2020-2024 | titanium tetrachloride | kg | N |
| titanium tetrachloride production | GLO | 2020-2024 | titanium tetrachloride | kg | U |
| treatment of residue from rutile production, synthetic, 56% water, residual material landfill | GLO | 1994-2000 | residue from rutile production, synthetic, 56% water | kg | PV |
| vanadium-titanomagnetite mine operation and beneficiation | CN; GLO | 2018-2022 | titania slag, 94% titanium dioxide | kg | N |
| zirconium oxide to generic market for electrolyte, for solid oxide fuel cell | GLO | 2021-2021 | electrolyte, for solid oxide fuel cell | kg | N |
| rutile production, synthetic, 95% titanium dioxide, Becher process | AU | 2004-2019 | rutile, 95% titanium dioxide | kg | N* |
| rutile production, synthetic, 95% titanium dioxide, Becher process | GLO | 2004-2019 | rutile, 95% titanium dioxide | kg | U |
| rutile production, synthetic, 95% titanium dioxide, Benelite process | GLO | 2000-2019 | rutile, 95% titanium dioxide | kg | PV |
| rutile production, synthetic, 95% titanium dioxide, Benelite process | IN | 2000-2019 | rutile, 95% titanium dioxide | kg | N* |
| scandium oxide production, from rare earth tailings | CN-NM; GLO | 2020-2024 | rare earth tailings, from bastnaesite and monazite ore | kg | N |
| scandium oxide to generic market for electrolyte, for solid oxide fuel cell | GLO | 2021-2021 | electrolyte, for solid oxide fuel cell | kg | N |
| sodium sulfate production, from natural sources | GLO; RER | 2000-2000 | sodium sulfate, anhydrite | kg | PV |
| sodium sulfide production | GLO | 2013-2013 | sodium sulfide | kg | PV |
| spodumene production | AU | 2000-2012 | spodumene | kg | N |
| spodumene production | GLO | 2000-2012 | spodumene | kg | U |
| spodumene production | RER | 2000-2000 | spodumene | kg | D |
| strontium carbonate production | GLO | 2014-2021 | strontium carbonate | kg | U |
| strontium mine operation and beneficiation | CN; ES; GLO | 2014-2020 | strontium sulfate, 90% SrSO4 | kg | N |
| strontium sulfate quarry operation | GLO | 2012-2012 | strontium sulfate, unprocessed | kg | U |
| tantalum mine operation and beneficiation | CD; GLO; RW | 2019-2023 | tantalum concentrate, 30% Ta2O5 | kg | N |
| tantalum powder production, capacitor-grade | CN; GLO | 2019-2023 | tantalum powder, capacitor-grade | kg | N |
| tantalum production, powder, capacitor-grade | GLO | 2000-2003 | tantalum, powder, capacitor-grade | kg | U |
| titanium dioxide production, chloride process | GLO; RER | 2005-2019 | titanium dioxide | kg | PV |
| titanium dioxide production, sulfate process | GLO; RER | 2005-2019 | titanium dioxide | kg | PV |
| titanium production | GLO | 2004-2004 | titanium | kg | U |

| Activity Name | Geography | Time Period | Product | Unit | v3.8 |
|---|---|---|---|---|---|
| titanium production, triple-melt | GLO | 2004-2004 | titanium, triple-melt | kg | U |
| titanium sponge production, from titanium tetrachloride | CN; GLO; JP | 2020-2024 | titanium sponge | kg | N |
| titanium tetrachloride production | CN; JP | 2020-2024 | titanium tetrachloride | kg | N |
| titanium tetrachloride production | GLO | 2020-2024 | titanium tetrachloride | kg | U |
| treatment of residue from rutile production, synthetic, 56% water, residual material landfill | GLO | 1994-2000 | residue from rutile production, synthetic, 56% water | kg | PV |
| vanadium-titanomagnetite mine operation and beneficiation | CN; GLO | 2018-2022 | titania slag, 94% titanium dioxide | kg | N |
| zirconium oxide to generic market for electrolyte, for solid oxide fuel cell | GLO | 2021-2021 | electrolyte, for solid oxide fuel cell | kg | N |
| titanium tetrachloride production | CN; JP | 2020-2024 | titanium tetrachloride | kg | N |
| titanium tetrachloride production | GLO | 2020-2024 | titanium tetrachloride | kg | U |
| treatment of residue from rutile production, synthetic, 56% water, residual material landfill | GLO | 1994-2000 | residue from rutile production, synthetic, 56% water | kg | PV |
| vanadium-titanomagnetite mine operation and beneficiation | CN; GLO | 2018-2022 | titania slag, 94% titanium dioxide | kg | N |
| zirconium oxide to generic market for electrolyte, for solid oxide fuel cell | GLO | 2021-2021 | electrolyte, for solid oxide fuel cell | kg | N |

## 12.2 Iron and steel

The production volumes of products in the iron and steel supply chain have been updated for most activities and geographies. Some GLO activities have exchange amounts that depend on the production volumes of the local datasets, therefore the exchanges amounts in those GLO activities have been updated as well.

With the update of production volumes, the iron ore supply chain has been restructured. While in v3.7.1, the GLO activity "iron ore mine operation and beneficiation" was the main supplier of the market for iron ore concentrate, for v3.8, its production volume is equal to that of CA-QC activity. Therefore, the RoW dataset is no longer created for that activity. Instead, the iron ore concentrate is supplied mainly through the GLO activity "iron ore mine operation, 46% Fe" followed by "iron ore beneficiation".

Table 40 lists the activities for which the production volume and other changes were made for version 3.8.

***Table 40. Updated datasets in the iron and steel supply chain.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column. In column v3.8, "PV" indicates that the only quantitative change was an update to the production volume of the output(s), while "U" stands for "Updated activity", which means that other changes were made in addition to the production volume.*

| Activity Name | Geography | Time Period | Product | Unit | v3.8 |
|---|---|---|---|---|---|
| cast iron production | GLO; RER | 2001-2002 | cast iron | kg | PV |
| hot rolling, steel | Europe without Austria | 1997-2002 | hot rolling, steel | kg | PV |
| hot rolling, steel | GLO | 1997-2002 | hot rolling, steel | kg | U |
| iron ore beneficiation | GLO | 1998-2000 | iron ore concentrate | kg | U |
| iron ore beneficiation | IN | 2007-2017 | iron ore concentrate | kg | PV |
| iron ore mine operation and beneficiation | CA-QC | 2011-2011 | iron ore concentrate | kg | PV |
| iron ore mine operation and beneficiation | GLO | 2011-2011 | iron ore concentrate | kg | U |
| iron ore mine operation, 46% Fe | GLO | 1999-2000 | iron ore, crude ore, 46% Fe | kg | PV |
| iron ore mine operation, 63% Fe | GLO; IN | 2000-2017 | iron ore, crude ore, 63% Fe | kg | PV |
| iron pellet production | CA-QC | 2011-2011 | iron pellet | kg | PV |
| iron pellet production | GLO | 1999-2002 | iron pellet | kg | U |
| iron pellet production | IN | 2010-2017 | iron pellet | kg | PV |
| iron sinter production | GLO; RER | 2005-2021 | iron sinter | kg | PV |
| iron sinter production | IN | 2007-2017 | iron sinter | kg | PV |
| pig iron production | GLO; RER | 2005-2021 | pig iron | kg | PV |
| pig iron production | IN | 2010-2017 | pig iron | kg | PV |
| sponge iron production | GLO | 2000-2017 | sponge iron | kg | U |
| sponge iron production | IN | 2000-2017 | sponge iron | kg | PV |
| steel production, chromium steel 18/8, hot rolled | GLO; RER | 2000-2002 | steel, chromium steel 18/8, hot rolled | kg | PV |
| steel production, converter, low-alloyed | GLO | 2013-2023 | steel, low-alloyed | kg | U |
| steel production, converter, low-alloyed | IN | 2010-2017 | steel, low-alloyed | kg | PV |
| steel production, converter, low-alloyed | RER | 2013-2023 | steel, low-alloyed | kg | PV |
| steel production, converter, unalloyed | GLO; RER | 2013-2023 | steel, unalloyed | kg | PV |
| steel production, electric, chromium steel 18/8 | GLO; RER | 2013-2023 | steel, chromium steel 18/8 | kg | PV |
| steel production, electric, low-alloyed | CA-QC | 2011-2011 | steel, low-alloyed | kg | U |
| steel production, electric, low-alloyed | CH | 2012-2012 | steel, low-alloyed | kg | U |
| steel production, electric, low-alloyed | Europe without Switzerland and Austria | 2013-2023 | steel, low-alloyed | kg | PV |
| steel production, electric, low-alloyed | GLO | 2010-2023 | steel, low-alloyed | kg | U |
| steel production, electric, low-alloyed | IN | 2010-2017 | steel, low-alloyed | kg | PV |
| steel production, low-alloyed, hot rolled | GLO; RER | 2000-2002 | steel, low-alloyed, hot rolled | kg | PV |

## 12.3 Smelting of copper concentrate

The activity "smelting of copper concentrate, sulfide ore" for all geographies (CL, CN, GLO, IN, JP and RU) have been updated in order to have more region-specific values for the exchange amounts. The regionalization is based on the approach used in the primary copper production datasets in Classen et al. (2009), using the same energy values as in the datasets in version 3.7.1 (Turner & Hischier 2019).

## 12.4 Precious metal for jewellery

The product "precious metal for jewellery" has been removed for version 3.8. It had originally been introduced for the purpose of substituting platinum with gold in the Consequential system model, as platinum was only produced as by-product in older versions of the ecoinvent database. As it is a reference product in the activity "platinum group metal, extraction and refinery operations", introduced in version 3.6, the product "precious metal for jewellery" is no longer needed. Therefore, the activities listed in Table 41 have been deleted for version 3.8.

***Table 41. Activities deleted for version 3.8 due to the removal of the product "precious metal for jewellery".***

| Activity Name | Geography | Time Period | Product | Unit |
|---|---|---|---|---|
| gold to generic market for precious metal for jewellery | GLO | 2005-2005 | precious metal for jewellery | m3 |
| market for precious metal for jewellery | GLO | 2005-2005 | precious metal for jewellery | m3 |
| platinum to generic market for precious metal for jewellery | GLO | 2005-2005 | precious metal for jewellery | m3 |

## 12.5 Other updates

Minor changes were made to other activities in relation to the metals sector. These are listed in Table 42.

***Table 42. Other activities updated in relation to the metal sector.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column. "AL" means that an "Activity Link" to a specific supplier was added in the dataset, while "U" stands for "Updated activity", meaning that other changes were made in addition to that.*

| Activity Name | Geography | Time Period | Product | Unit | v3.8 |
|---|---|---|---|---|---|
| ammonium paratungstate production, solvent extraction | AT; DE; GLO; US | 1979-2020 | ammonium paratungstate | kg | U |
| cobalt production | GLO | 2012-2020 | cobalt;<br>cobalt acetate;<br>cobalt carbonate;<br>cobalt hydroxide;<br>cobalt oxide | kg;<br>kg;<br>kg;<br>kg;<br>kg | AL |
| fish curing plant construction and maintenance | PE | 2011-2012 | fish curing plant | unit | AL |

# 13 Transport

## 13.1 Air freight transport

The air freight transport datasets ("transport, freight, aircraft, dedicated freight, […] haul" and "transport, freight, aircraft, belly-freight, […] haul") were updated within the release of ecoinvent v3.8 in collaboration with INFRAS, the original data provider. An updated project report (Notten P.J., Althaus H-J. and Cox B., (2021) Life cycle inventories of global air freight – Global, Update 2021. ecoinvent Association, Zürich, Switzerland) is accessible in the SRI results section of the ecoinvent website.

***Table 43. Updated activities related to air freight transport.***

| Activity Name | Geography | Time Period | Reference product | Unit |
|---|---|---|---|---|
| transport, freight, aircraft, belly-freight, long haul | GLO | 2016-2016 | transport, freight, aircraft, long haul | metric ton*km |
| transport, freight, aircraft, belly-freight, medium haul | GLO | 2016-2016 | transport, freight, aircraft, medium haul | metric ton*km |
| transport, freight, aircraft, belly-freight, short haul | GLO | 2016-2016 | transport, freight, aircraft, short haul | metric ton*km |
| transport, freight, aircraft, belly-freight, very short haul | GLO | 2016-2016 | transport, freight, aircraft, very short haul | metric ton*km |
| transport, freight, aircraft, dedicated freight, long haul | GLO | 2016-2016 | transport, freight, aircraft, long haul | metric ton*km |
| transport, freight, aircraft, dedicated freight, medium haul | GLO | 2016-2016 | transport, freight, aircraft, medium haul | metric ton*km |
| transport, freight, aircraft, dedicated freight, short haul | GLO | 2016-2016 | transport, freight, aircraft, short haul | metric ton*km |
| transport, freight, aircraft, dedicated freight, very short haul | GLO | 2016-2016 | transport, freight, aircraft, very short haul | metric ton*km |

The consumption of kerosene, and the corresponding emissions, were underestimated. These incorrect values were present in version 3.6, 3.7 and 3.7.1. The updated amounts of fuel are reported in the table below.

***Table 44. Updated kerosene amount (kg/tkm) for activities related to air freight transport.***

| Activity Name | Geography | Unit | v3.7.1 | v3.8 |
|---|---|---|---|---|
| transport, freight, aircraft, belly-freight, long haul | kerosene | kg | 0.113 | 0.214 |
| transport, freight, aircraft, belly-freight, medium haul | kerosene | kg | 0.142 | 0.189 |
| transport, freight, aircraft, belly-freight, short haul | kerosene | kg | 0.176 | 0.206 |
| transport, freight, aircraft, belly-freight, very short haul | kerosene | kg | 0.239 | 0.268 |
| transport, freight, aircraft, dedicated freight, long haul | kerosene | kg | 0.094 | 0.201 |
| transport, freight, aircraft, dedicated freight, medium haul | kerosene | kg | 0.058 | 0.233 |
| transport, freight, aircraft, dedicated freight, short haul | kerosene | kg | 0.040 | 0.272 |
| transport, freight, aircraft, dedicated freight, very short haul | kerosene | kg | 0.034 | 0.347 |

This correction leads to significant changes in the LCIA scores for air freight transport data. In the ecoinvent database there are only 42 activities that require air transport as a direct input. For few of these,

the update of transport has a relevant impact, particularly for the markets of fruits and vegetables such as green and white asparagus, papaya, pineapple, and strawberry.

To support users in the assessment of this update, a file is available in the Files section of ecoQuery. The information contained are:

- The exchange amounts in version 3.7.1 are listed side by side the updated values included in version 3.8. This information is reported for the database in its undefined form as well as for all three system models. Users have therefore the possibility of correcting the data in the previously affected versions of the ecoinvent database (3.6, 3.7 and 3.7.1).

- The relative change in impact assessment scores for the air freight transport data and all activities that have a direct inputs of air transport. The information is shown for different impact assessment methods and for all three system models. Users can consult this file to assess the eventual impact of the update of air transport data on activities relevant for their work.

### 13.2 Supply Chains for Liquefied Petroleum Gas

The supply chains for liquefied petroleum gas (LPG) were updated by changing the type of ship used for the input for transoceanic shipping, from ‘tanker for petroleum’ to ‘tanker for liquefied natural gas’ This meant that both the global market activity, as well as the import activities to regional markets for LPG, now receive ‘transport, freight, sea, tanker for liquefied natural gas’ as an input instead. Furthermore, a new regional market activity and an import activity from RoW were created for Colombia (CO), following the approach described in Fehrenbach et al. (2018), as listed in Table 45.

***Table 45. New and updated activities in liquefied petroleum gas (LPG) supply chains.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column. In the column v.3.8, “N” stands for “New Activity”, “U” stands for “Updated Activity”.*

| Activity name | Geography | Time Period | Product Name | Unit | v3.8 |
|---|---|---|---|---|---|
| liquefied petroleum gas, import from RoW | CO | 2014-2017 | liquefied petroleum gas | kg | N |
| liquefied petroleum gas, import from RoW | BR; Europe without Switzerland; IN; PE; ZA | 2014-2017 | liquefied petroleum gas | kg | U |
| market for liquefied petroleum gas | GLO | 1980-2010 | liquefied petroleum gas | kg | U |
| market for liquefied petroleum gas | CO | 2014-2017 | liquefied petroleum gas | kg | N |

## 13.3 Other updates

Other corrections have been done in the sector, to adjust properties of products (container) or to adjust the amounts of waste produced (road).

***Table 46. Other updated activities in the sector.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity name | Geography | Time Period | Product Name | Unit |
|---|---|---|---|---|
| intermodal shipping container production, 20-foot | GLO | 2010-2014 | intermodal shipping container, 20-foot | unit |
| intermodal shipping container production, 40-foot, high-cube | GLO | 2010-2014 | intermodal shipping container, 40-foot, high-cube | unit |
| road construction | CH; GLO | 1990-2000 | road | m*year |

# 14 Other sectors

For every release, the database is inspected and identified errors and improvements are corrected or applied. This chapter groups those kinds of updates, that have not been included in any of the previous chapters, focused on sectors that experienced large updates.

## 14.1 Accommodation services

The construction activities have been adjusted (input of plywood and corresponding waste). A summary can be found below.

***Table 47. Updated activities in the sector.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity Name | Geography | Time Period | Product | Unit |
|---|---|---|---|---|
| building construction, budget hotel | PE | 2017-2018 | building, budget hotel | unit |
| building construction, luxury hotel | BR; PE | 2017-2018 | building, luxury hotel | unit |

## 14.2 Waste sector

Corrections in this sector affect the dataset listed in the following table. The land occupation of composting was overestimated, the correction affects the results measured with related indicators.

***Table 48. Updated activities in the sector.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

| Activity Name | Geography | Time Period | Product | Unit |
|---|---|---|---|---|
| treatment of garden biowaste, home composting in heaps | FR; GLO | 2014-2015 | biowaste, garden waste | kg |
| direct disposal of wastewater from textile production | GLO | 2017-2018 | wastewater from textile production | m3 |

## 14.3 Varia

This section groups different updates and corrections done to the database, not documented elsewhere in this report.

***Table 49. Updated activities with various modifications.*** *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column. In column "v3.8" "AL" means that an "Activity Link" to a specific supplier was added in the dataset, while "U" stands for "Updated activity", meaning that other changes were made in addition to that.*

| Activity Name | Geography | Time Period | Product | Unit | v3.8 |
|---|---|---|---|---|---|
| air compressor production, screw-type compressor, 300kW | GLO | 2006-2007 | air compressor, screw-type compressor, 300kW | unit | U |
| air compressor production, screw-type compressor, 300kW | RER | 2006-2007 | air compressor, screw-type compressor, 300kW | unit | U |
| air compressor production, screw-type compressor, 4kW | GLO | 2006-2007 | air compressor, screw-type compressor, 4kW | unit | U |
| air compressor production, screw-type compressor, 4kW | RER | 2006-2007 | air compressor, screw-type compressor, 4kW | unit | U |
| coating service, melamine impregnated paper, double-sided | GLO; RER | 2012-2012 | coating, with melamine impregnated paper | m2 | U |
| cooling energy, from natural gas, at cogen unit with absorption chiller 100kW | CH; GLO | 2000-2005 | cooling energy | MJ | AL |
| fuel cell production, stack polymer electrolyte membrane, 2kW electrical, future | CH | 2000-2005 | fuel cell, stack polymer electrolyte membrane, 2kW electrical, future | unit | U |
| ion-exchanger production for water treatment | CH; GLO | 1992-2002 | ion-exchanger for water treatment | unit | U |

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# Annex 1: Indicators

CML 2001 (superseded)-acidification potential-average European; CML 2001 (superseded)-acidification potential-generic; CML 2001 (superseded)-climate change-GWP 500a; CML 2001 (superseded)-climate change-lower limit of net GWP; CML 2001 (superseded)-climate change-GWP 100a; CML 2001 (superseded)-climate change-GWP 20a; CML 2001 (superseded)-climate change-upper limit of net GWP; CML 2001 (superseded)-eutrophication potential-average European; CML 2001 (superseded)-eutrophication potential-generic; CML 2001 (superseded)-freshwater aquatic ecotoxicity-FAETP infinite; CML 2001 (superseded)-freshwater aquatic ecotoxicity-FAETP 100a; CML 2001 (superseded)-freshwater aquatic ecotoxicity-FAETP 20a; CML 2001 (superseded)-freshwater aquatic ecotoxicity-FAETP 500a; CML 2001 (superseded)-freshwater sediment ecotoxicity-FSETP infinite; CML 2001 (superseded)-freshwater sediment ecotoxicity-FSETP 20a; CML 2001 (superseded)-freshwater sediment ecotoxicity-FSETP 500a; CML 2001 (superseded)-freshwater sediment ecotoxicity-FSETP 100a; CML 2001 (superseded)-human toxicity-HTP 500a; CML 2001 (superseded)-human toxicity-HTP 20a; CML 2001 (superseded)-human toxicity-HTP 100a; CML 2001 (superseded)-human toxicity-HTP infinite; CML 2001 (superseded)-ionising radiation-ionising radiation; CML 2001 (superseded)-land use-competition; CML 2001 (superseded)-malodours air-malodours air; CML 2001 (superseded)-marine aquatic ecotoxicity-MAETP 100a; CML 2001 (superseded)-marine aquatic ecotoxicity-MAETP 20a; CML 2001 (superseded)-marine aquatic ecotoxicity-MAETP 500a; CML 2001 (superseded)-marine aquatic ecotoxicity-MAETP infinite; CML 2001 (superseded)-marine sediment ecotoxicity-MSETP 500a; CML 2001 (superseded)-marine sediment ecotoxicity-MSETP 20a; CML 2001 (superseded)-marine sediment ecotoxicity-MSETP infinite; CML 2001 (superseded)-marine sediment ecotoxicity-MSETP 100a; CML 2001 (superseded)-photochemical oxidation (summer smog)-EBIR; CML 2001 (superseded)-photochemical oxidation (summer smog)-MIR; CML 2001 (superseded)-photochemical oxidation (summer smog)-high NOx POCP; CML 2001 (superseded)-photochemical oxidation (summer smog)-low NOx POCP; CML 2001 (superseded)-photochemical oxidation (summer smog)-MOIR; CML 2001 (superseded)-resources-depletion of abiotic resources; CML 2001 (superseded)-stratospheric ozone depletion-ODP 25a; CML 2001 (superseded)-stratospheric ozone depletion-ODP 5a; CML 2001 (superseded)-stratospheric ozone depletion-ODP 40a; CML 2001 (superseded)-stratospheric ozone depletion-ODP 15a; CML 2001 (superseded)-stratospheric ozone depletion-ODP 20a; CML 2001 (superseded)-stratospheric ozone depletion-ODP steady state; CML 2001 (superseded)-stratospheric ozone depletion-ODP 30a; CML 2001 (superseded)-stratospheric ozone depletion-ODP 10a; CML 2001 (superseded)-terrestrial ecotoxicity-TAETP infinite; CML 2001 (superseded)-terrestrial ecotoxicity-TAETP 100a; CML 2001 (superseded)-terrestrial ecotoxicity-TAETP 500a; CML 2001 (superseded)-terrestrial ecotoxicity-TAETP 20a; cumulative energy demand-biomass-renewable energy resources, biomass; cumulative energy demand-fossil-non-renewable energy resources, fossil; cumulative energy demand-geothermal-renewable energy resources, geothermal, converted; cumulative energy demand-nuclear-non-renewable energy resources, nuclear; cumulative energy demand-primary forest-non-renewable energy resources, primary forest; cumulative energy demand-solar-renewable energy resources, solar, converted; cumulative energy demand-water-renewable energy resources, potential (in barrage water), converted; cumulative energy demand-wind-renewable energy resources, kinetic (in wind), converted; cumulative exergy demand-biomass-renewable energy resources, biomass; cumulative exergy demand-fossil-non-renewable energy resources, fossil; cumulative exergy demand-metals-non-renewable material resources, metals; cumulative exergy demand-minerals-non-renewable material resources, minerals; cumulative exergy demand-nuclear-non-renewable energy resources, nuclear; cumulative exergy demand-primary forest-non-renewable energy resources, primary forest; cumulative exergy demand-solar-renewable energy resources, solar, converted; cumulative exergy demand-water-renewable energy resources, potential (in barrage water), converted; cumulative exergy demand-water resources-renewable material resources, water; cumulative exergy demand-wind-renewable energy resources, kinetic (in wind), converted; eco-indicator 99, (E,E) (superseded)-ecosystem quality-land occupation; eco-indicator 99, (E,E) (superseded)-ecosystem quality-acidification & eutrophication; eco-indicator 99, (E,E) (superseded)-ecosystem quality-total; eco-indicator 99, (E,E) (superseded)-ecosystem quality-ecotoxicity; eco-indicator 99, (E,E) (superseded)-human health-ozone layer depletion; eco-indicator 99, (E,E) (superseded)-human health-total; eco-indicator 99, (E,E) (superseded)-human health-ionising radiation; eco-indicator 99, (E,E) (superseded)-human health-respiratory effects; eco-indicator 99, (E,E)

(superseded)-human health-carcinogenics; eco-indicator 99, (E,E) (superseded)-human health-climate change; eco-indicator 99, (E,E) (superseded)-resources-total; eco-indicator 99, (E,E) (superseded)-resources-mineral extraction; eco-indicator 99, (E,E) (superseded)-resources-fossil fuels; eco-indicator 99, (E,E) (superseded)-total-total; eco-indicator 99, (H,A) (superseded)-ecosystem quality-land occupation; eco-indicator 99, (H,A) (superseded)-ecosystem quality-acidification & eutrophication; eco-indicator 99, (H,A) (superseded)-ecosystem quality-total; eco-indicator 99, (H,A) (superseded)-ecosystem quality-ecotoxicity; eco-indicator 99, (H,A) (superseded)-human health-ionising radiation; eco-indicator 99, (H,A) (superseded)-human health-respiratory effects; eco-indicator 99, (H,A) (superseded)-human health-carcinogenics; eco-indicator 99, (H,A) (superseded)-human health-ozone layer depletion; eco-indicator 99, (H,A) (superseded)-human health-total; eco-indicator 99, (H,A) (superseded)-human health-climate change; eco-indicator 99, (H,A) (superseded)-resources-fossil fuels; eco-indicator 99, (H,A) (superseded)-resources-total; eco-indicator 99, (H,A) (superseded)-resources-mineral extraction; eco-indicator 99, (H,A) (superseded)-total-total; eco-indicator 99, (I,I) (superseded)-ecosystem quality-total; eco-indicator 99, (I,I) (superseded)-ecosystem quality-acidification & eutrophication; eco-indicator 99, (I,I) (superseded)-ecosystem quality-ecotoxicity; eco-indicator 99, (I,I) (superseded)-ecosystem quality-land occupation; eco-indicator 99, (I,I) (superseded)-human health-climate change; eco-indicator 99, (I,I) (superseded)-human health-total; eco-indicator 99, (I,I) (superseded)-human health-ozone layer depletion; eco-indicator 99, (I,I) (superseded)-human health-ionising radiation; eco-indicator 99, (I,I) (superseded)-human health-respiratory effects; eco-indicator 99, (I,I) (superseded)-human health-carcinogenics; eco-indicator 99, (I,I) (superseded)-resources-mineral extraction; eco-indicator 99, (I,I) (superseded)-resources-total; eco-indicator 99, (I,I) (superseded)-total-total; ecological footprint-total-land occupation; ecological footprint-total-nuclear; ecological footprint-total-CO2; ecological footprint-total-total; ecological scarcity 2013-carcinogenic substances into air-total; ecological scarcity 2013-energy resources-total; ecological scarcity 2013-global warming-total; ecological scarcity 2013-heavy metals into air-total; ecological scarcity 2013-heavy metals into soil-total; ecological scarcity 2013-heavy metals into water-total; ecological scarcity 2013-land use-total; ecological scarcity 2013-main air pollutants and PM-total; ecological scarcity 2013-mineral resources-total; ecological scarcity 2013-non radioactive waste to deposit-total; ecological scarcity 2013-ozone layer depletion-total; ecological scarcity 2013-pesticides into soil-total; ecological scarcity 2013-POP into water-total; ecological scarcity 2013-radioactive substances into air-total; ecological scarcity 2013-radioactive substances into water-total; ecological scarcity 2013-radioactive waste to deposit-total; ecological scarcity 2013-total-total; ecological scarcity 2013-water pollutants-total; ecological scarcity 2013-water resources-total; ecosystem damage potential-total-linear, land use, total; ecosystem damage potential-total-linear, land occupation; ecosystem damage potential-total-linear, land transformation; EDIP2003-acidification-acidification; EDIP2003-ecotoxicity-in sewage treatment plants; EDIP2003-ecotoxicity-acute, in water; EDIP2003-ecotoxicity-chronic, in soil; EDIP2003-ecotoxicity-chronic, in water; EDIP2003-eutrophication-terrestrial eutrophication; EDIP2003-eutrophication-separate N potential; EDIP2003-eutrophication-separate P potential; EDIP2003-eutrophication-combined potential; EDIP2003-global warming-GWP 100a; EDIP2003-global warming-GWP 500a; EDIP2003-global warming-GWP 20a; EDIP2003-human toxicity-via soil; EDIP2003-human toxicity-via air; EDIP2003-human toxicity-via surface water; EDIP2003-land filling-radioactive waste; EDIP2003-land filling-slag and ashes; EDIP2003-land filling-hazardous waste; EDIP2003-land filling-bulk waste; EDIP2003-photochemical ozone formation-impacts on vegetation; EDIP2003-photochemical ozone formation-impacts on human health; EDIP2003-renewable resources-wood; EDIP2003-stratospheric ozone depletion-ODP total; EF v2.0 2018-climate change-global warming potential (GWP100); EF v2.0 2018-climate change: biogenic-global warming potential (GWP100); EF v2.0 2018-climate change: fossil-global warming potential (GWP100); EF v2.0 2018-climate change: land use and land use change-global warming potential (GWP100); EF v2.0 2018-acidification-accumulated exceedance (ae); EF v2.0 2018-eutrophication: freshwater-fraction of nutrients reaching freshwater end compartment (P); EF v2.0 2018-eutrophication: terrestrial-accumulated exceedance (AE) ; EF v2.0 2018-ecotoxicity: freshwater-comparative toxic unit for ecosystems (CTUe) ; EF v2.0 2018-eutrophication: marine-fraction of nutrients reaching marine end compartment (N); EF v2.0 2018-photochemical ozone formation: human health-tropospheric ozone concentration increase; EF v2.0 2018-human toxicity: carcinogenic-comparative toxic unit for human (CTUh) ; EF v2.0 2018-human toxicity: non-carcinogenic-comparative toxic unit for human (CTUh) ; EF v2.0 2018-particulate matter formation-impact on human health; EF v2.0 2018-ozone depletion-ozone depletion potential (ODP) ; EF v2.0 2018-ionising

radiation: human health-human exposure efficiency relative to u235; EF v2.0 2018-land use-soil quality index; EF v2.0 2018-material resources: metals/minerals-abiotic depletion potential (ADP): elements (ultimate reserves); EF v2.0 2018-energy resources: non-renewable-abiotic depletion potential (ADP): fossil fuels; EF v2.0 2018-water use-user deprivation potential (deprivation-weighted water consumption); EPS 2000-total-emissions into soil; EPS 2000-total-abiotic stock resources; EPS 2000-total-emissions into air; EPS 2000-total-total; EPS 2000-total-emissions into water; EPS 2000-total-land occupation; IMPACT 2002+ (Endpoint)-climate change-climate change; IMPACT 2002+ (Endpoint)-climate change-total; IMPACT 2002+ (Endpoint)-ecosystem quality-terrestrial acidification & nutrification; IMPACT 2002+ (Endpoint)-ecosystem quality-aquatic ecotoxicity; IMPACT 2002+ (Endpoint)-ecosystem quality-land occupation; IMPACT 2002+ (Endpoint)-ecosystem quality-total; IMPACT 2002+ (Endpoint)-ecosystem quality-terrestrial ecotoxicity; IMPACT 2002+ (Endpoint)-human health-respiratory effects (inorganics); IMPACT 2002+ (Endpoint)-human health-human toxicity; IMPACT 2002+ (Endpoint)-human health-ozone layer depletion; IMPACT 2002+ (Endpoint)-human health-photochemical oxidation; IMPACT 2002+ (Endpoint)-human health-total; IMPACT 2002+ (Endpoint)-human health-ionising radiation; IMPACT 2002+ (Endpoint)-resources-total; IMPACT 2002+ (Endpoint)-resources-non-renewable energy; IMPACT 2002+ (Endpoint)-resources-mineral extraction; IMPACT 2002+ (Midpoint)-ecosystem quality-aquatic eutrophication; IMPACT 2002+ (Midpoint)-ecosystem quality-aquatic acidification; IPCC 2013-climate change-GTP 100a; IPCC 2013-climate change-GWP 100a; IPCC 2013-climate change-GTP 20a; IPCC 2013-climate change-GWP 20a; ReCiPe Midpoint (E) V1.13-agricultural land occupation-ALOP; ReCiPe Midpoint (E) V1.13-climate change-GWP500; ReCiPe Midpoint (E) V1.13-fossil depletion-FDP; ReCiPe Midpoint (E) V1.13-freshwater ecotoxicity-FETPinf; ReCiPe Midpoint (E) V1.13-freshwater eutrophication-FEP; ReCiPe Midpoint (E) V1.13-human toxicity-HTPinf; ReCiPe Midpoint (E) V1.13-ionising radiation-IRP_HE; ReCiPe Midpoint (E) V1.13-marine ecotoxicity-METPinf; ReCiPe Midpoint (E) V1.13-marine eutrophication-MEP; ReCiPe Midpoint (E) V1.13-metal depletion-MDP; ReCiPe Midpoint (E) V1.13-natural land transformation-NLTP; ReCiPe Midpoint (E) V1.13-ozone depletion-ODPinf; ReCiPe Midpoint (E) V1.13-particulate matter formation-PMFP; ReCiPe Midpoint (E) V1.13-photochemical oxidant formation-POFP; ReCiPe Midpoint (E) V1.13-terrestrial acidification-TAP500; ReCiPe Midpoint (E) V1.13-terrestrial ecotoxicity-TETPinf; ReCiPe Midpoint (E) V1.13-urban land occupation-ULOP; ReCiPe Midpoint (E) V1.13-water depletion-WDP; ReCiPe Midpoint (H) V1.13-agricultural land occupation-ALOP; ReCiPe Midpoint (H) V1.13-climate change-GWP100; ReCiPe Midpoint (H) V1.13-fossil depletion-FDP; ReCiPe Midpoint (H) V1.13-freshwater ecotoxicity-FETPinf; ReCiPe Midpoint (H) V1.13-freshwater eutrophication-FEP; ReCiPe Midpoint (H) V1.13-human toxicity-HTPinf; ReCiPe Midpoint (H) V1.13-ionising radiation-IRP_HE; ReCiPe Midpoint (H) V1.13-marine ecotoxicity-METPinf; ReCiPe Midpoint (H) V1.13-marine eutrophication-MEP; ReCiPe Midpoint (H) V1.13-metal depletion-MDP; ReCiPe Midpoint (H) V1.13-natural land transformation-NLTP; ReCiPe Midpoint (H) V1.13-ozone depletion-ODPinf; ReCiPe Midpoint (H) V1.13-particulate matter formation-PMFP; ReCiPe Midpoint (H) V1.13-photochemical oxidant formation-POFP; ReCiPe Midpoint (H) V1.13-terrestrial acidification-TAP100; ReCiPe Midpoint (H) V1.13-terrestrial ecotoxicity-TETPinf; ReCiPe Midpoint (H) V1.13-urban land occupation-ULOP; ReCiPe Midpoint (H) V1.13-water depletion-WDP; ReCiPe Midpoint (I) V1.13-agricultural land occupation-ALOP; ReCiPe Midpoint (I) V1.13-climate change-GWP20; ReCiPe Midpoint (I) V1.13-fossil depletion-FDP; ReCiPe Midpoint (I) V1.13-freshwater ecotoxicity-FETP100; ReCiPe Midpoint (I) V1.13-freshwater eutrophication-FEP; ReCiPe Midpoint (I) V1.13-human toxicity-HTP100; ReCiPe Midpoint (I) V1.13-ionising radiation-IRP_I; ReCiPe Midpoint (I) V1.13-marine ecotoxicity-METP100; ReCiPe Midpoint (I) V1.13-marine eutrophication-MEP; ReCiPe Midpoint (I) V1.13-metal depletion-MDP; ReCiPe Midpoint (I) V1.13-natural land transformation-NLTP; ReCiPe Midpoint (I) V1.13-ozone depletion-ODPinf; ReCiPe Midpoint (I) V1.13-particulate matter formation-PMFP; ReCiPe Midpoint (I) V1.13-photochemical oxidant formation-POFP; ReCiPe Midpoint (I) V1.13-terrestrial acidification-TAP20; ReCiPe Midpoint (I) V1.13-terrestrial ecotoxicity-TETP100; ReCiPe Midpoint (I) V1.13-urban land occupation-ULOP; ReCiPe Midpoint (I) V1.13-water depletion-WDP; TRACI-environmental impact-photochemical oxidation; TRACI-environmental impact-global warming; TRACI-environmental impact-eutrophication; TRACI-environmental impact-acidification; TRACI-environmental impact-ozone depletion; TRACI-environmental impact-ecotoxicity; TRACI-human health-non-carcinogenics; TRACI-human health-respiratory effects, average; TRACI-human health-carcinogenics; USEtox-ecotoxicity-total; USEtox-human toxicity-total; USEtox-human toxicity-non-carcinogenic; USEtox-human toxicity-carcinogenic;

# Annex 2: Products with updated prices

barite; cerium oxide; cobalt; cobalt acetate; cobalt carbonate; cobalt hydroxide; cobalt oxide; diesel; europium oxide; fluorspar, 97% purity; heavy fuel oil; ilmenite, 54% titanium dioxide; kerosene; lanthanum oxide; lanthanum-cerium oxide; laterite, mineral; light fuel oil; liquefied petroleum gas; naphtha; natural gas, high pressure; petrol, unleaded; phosphorus oxychloride; pitch; praseodymium-neodymium oxide; rutile, 95% titanium dioxide; samarium oxide; sulfur; titania slag, 85% titanium dioxide; yttrium oxide; zinc; zircon, 50% zirconium