Documentation of changes implemented in the ecoinvent database v3.10 (2023.11.28)

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Table of Contents

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1 Introduction to the new version

This report covers the changes to the ecoinvent database between version 3.9.1, released in 2022 and version 3.10, released in 2023. It describes both the database-wide changes that affect the whole database as well as the specific changes in the different sectors. These changes consist in the addition of new datasets, in the deletion of outdated ones, and in the update of others.

All changes described in this report potentially affect or modify impact assessment results, even when they seem as minor as changing an activity link. The description of the changes has been provided to help the users with the interpretation and understanding of the possible changes in results they might encounter when comparing version 3.9.1 with version 3.10.

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 datasets available in version 3.9.1 and 3.10, with an indication of what changed. Changes that may affect the LCIA scores are reported.

The Correspondence File, which is available on the ecoinvent website, provides for each system model a mapping of datasets between versions 3.9.1 and 3.10, which indicates which new datasets are available in cases where datasets in the previous version have been deleted or replaced.

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

The main data updates for each sector are the following:

- Petroleum and Natural Gas: Version 3.10 features an extensive full-scale update of petroleum and natural gas supply chains, incorporating the latest statistical data from 2021.
- Other Fuels: Version 3.10 will introduce data modeling for the production of hard coal coke in China.
- Chemicals: Unit process data for olefins and aromatics have replaced aggregated data. Additionally, new datasets modeling the production of hydrogen, methanol, chlorine, and cooling energy supply have been added.
- Electricity: Market mixes have been updated with data from 2020, and for select countries like China, India, and the United States, data from 2021 has been included. The residual mix markets for EU-28 and several other European countries have been refreshed based on 2022 data.
- Waste: Version 3.10 contains fully disaggregated waste treatment chains, offering a more in-depth view of environmental impacts associated with waste treatment steps.
- Agriculture: Datasets covering barley, oat, wheat, and rapeseed production in Australia, as well as data for potato, sweet corn, soybean, and maize production

in the United States have been added for version 3.10. This includes detailed data modeling machinery and field operations in both countries.

- Construction: Regionalized data for various construction materials, covering Tunisia, Ecuador, and Switzerland, have been introduced.

In addition to new and updated data, version 3.10 includes some useful updates related to the exchanges. The Harmonized System (HS), which is a nomenclature for the classification of products developed by the World Customs Organization (WCO), has been added to the database. Every intermediate exchange will have a classification according to the HS system, in addition to the Central Product Classification (CPC) which has been available in previous versions.

Finally, new impact assessment methods have been introduced for v3.10, and characterization factors have been updated for certain elementary exchanges in specific methods.

2 Database-wide changes

2.1 Renamed activities

Some activities were renamed for version 3.10. The changes are listed in **Table 1**.

Table 1. Activities renamed for v3.10. Most of the activity name changes aim at better defining the scope of the activity. More details of some changes are given in the corresponding chapters.

Activity Name v3.9.1	Activity Name v3.10
1,1-difluoroethane production, HFC-152a	1,1-difluoroethane production
acetaldehyde oxidation	acetic anhydride production, acetaldehyde oxidation
acetaldehyde production	acetaldehyde production, ethylene oxidation
acetic acid production, product in 98% solution state	acetic acid production, methanol carboxylation (Monsanto), product in 98% solution state
acetic anhydride production, ketene route	acetic anhydride production, acetic acid pyrolysis, via ketene intermediate
acrylic dispersion production, with water, in 58% solution	acrylic dispersion production, with water, in 58% solution state
air separation, cryogenic	industrial gases production, cryogenic air separation
air separation, xenon krypton purification	xenon and krypton purification, air separation
amination of chlorosilane	hexamethyldisilazane production, amination of chlorosilane
amine oxide production	amine oxides production
asbestos production, crysotile type	asbestos production, chrysotile type
barley production	barley grain production
barley production, organic	barley grain production, organic
barley production, Swiss integrated production, extensive	barley grain production, Swiss integrated production, extensive
barley production, Swiss integrated production, intensive	barley grain production, Swiss integrated production, intensive
battery production, NaCl, rechargeable	battery production, Na-NiCl, rechargeable
benzene chlorination	chlorobenzenes production, benzene chlorination
Brown-Schlesinger process	sodium tetrahydridoborate production, Brown-Schlesinger process
butane-1,4-diol production	1,4-butanediol production
chichibabin amination	aminopyridine production, Chichibabin amination
chichibabin pyridine synthesis	pyridine production, Chichibabin process
chlorofluorination of ethylene	monochloropentafluoroethane production, chlorofluorination of ethylene
chromium oxide production, flakes	chromium trioxide production, flakes
clay brick production	clay brick production, extruded

coking	coke production
cumene production	cumene production, benzene alkylation
cyclohexane production	cyclohexane production, benzene hydrogenation, liquid phase process
decarboxylative cyclization of adipic acid	2-cyclopentanone production, decarboxylative cyclization of adipic acid
dehydrogenation of butan-1,4-diol	butyrolactone production, dehydrogenation of 1,4-butanediol
dichloropropene to generic market for pesticide, unspecified	1,3-dichloropropene to generic market for pesticide, unspecified
DTPA production	diethylenetriaminepentaacetic acid production, alkaline cyanomethylation of diethylenetriamine
EDTA production	ethylenediaminetetraacetic acid production, alkaline cyanomethylation of ethylenediamine
electrolysis of lithium chloride	lithium production, lithium chloride electrolysis
ethylene glycol production	ethylene glycols production, thermal hydrolysis of ethylene oxide
ethylene hydration	ethanol production, ethylene hydration
ethylene oxide production	ethylene oxide production, ethylene oxidation
ethylenediamine production, from ethanolamine	ethylene diamine production, from ethanolamine
ethylenediamine production, from ethylene dichloride	ethylene diamine production, from ethylene dichloride
fluorination of sodium tetrahydridoborate	sodium tetrafluoroborate production, sodium tetrahydridoborate fluorination
hydroformylation of butene	pentanols production, hydroformylation of butene
hydroformylation of propylene	butanols production, hydroformylation of propylene
hydrogen production, steam reforming	hydrogen production, steam methane reforming
Mannheim process	hydrochloric acid production, Mannheim process
market for 1,1-difluoroethane, HFC-152a	market for 1,1-difluoroethane
market for 2,3-dimethylbutan	market for 2,3-dimethylbutane
market for 2-cyclopentone	market for 2-cyclopentanone
market for acrylic dispersion, with water, in 58% solution	market for acrylic dispersion, with water, in 58% solution state
market for amine oxide	market for amine oxides
market for asbestos, crysotile type	market for asbestos, chrysotile type
market for butane-1,4-diol	market for 1,4-butanediol
market for chromium oxide, flakes	market for chromium trioxide, flakes
market for dichloropropene	market for 1,3-dichloropropene
market for ethylenediamine	market for ethylene diamine
market for hydrogen, gaseous	market for hydrogen, gaseous, low pressure
market for hydrogen, liquid	market for hydrogen, gaseous, medium pressure, merchant

market for maintenance, tanker for liquid goods other than petroleum and liquefied natural gas	market for maintenance, tanker, for liquid goods other than petroleum and liquefied natural gas
market for methane sulfonic acid	market for methylsulfonic acid
market for methyl tert-butyl ether	market for methyl t-butyl ether
market for ortho-phenylene diamine	market for o-phenylene diamine
market for para-phenylene diamine	market for p-phenylene diamine
market for polylactide, granulate	market for polylactic acid, granulate
market for roof tile	market for clay roof tile
market for tert-butyl amine	market for t-butyl amine
market for triazine-compound, unspecified	market for triazine-compound
market for trichloromethane	market for chloroform
market for used refrigerant R-12	market for used refrigerant R12
market for used refrigerant R-600a	market for used refrigerant R600a
market for xylene	market for xylene, mixed
methane sulfonic acid production	methylsulfonic acid production
methanol production	methanol production, natural gas reforming
methanol production, from synthetic gas	methanol production, biomass gasification
methyl tert-butyl ether production	methyl t-butyl ether production
modified Solvay process, Hou's process	soda ash production, dense, Hou's process
molecular sieve separation of naphtha	hydrocarbons purification, molecular sieve separation of naphtha
N,N-dimethylformamide production	N,N-dimethylformamide production, direct synthesis
oat production	oat grain production
ortho-phenylene diamine production	o-phenylene diamine production
oxidation of butane	acetic acid production, butane oxidation
oxidation of manganese dioxide	potassium permanganate production, manganese dioxide oxidation
oxidation of methanol	formaldehyde production, methanol oxidation
para-phenylene diamine production	p-phenylene diamine production
phenol production, from cumene	phenol production, cumene oxidation
phthalic anhydride production	phthalic anhydride production, o-xylene oxidation
p-nitrotoluene production	nitrotoluenes production, toluene nitration
polylactide production, granulate	polylactic acid production, granulate
roof tile production	clay roof tile production
silicon hydrochloration	silicon tetrahydride production, silicon hydrochlorination

sodium chloride electrolysis	sodium production, sodium chloride electrolysis, molten salt cell
Sohio process	acrylonitrile production, Sohio process
tert-butyl amine production	t-butyl amine production
toluene oxidation	benzoic acid production, toluene oxidation
treatment of aluminium in car shredder residue, municipal incineration with fly ash extraction	treatment of aluminium in car shredder residue, municipal incineration FAE
treatment of biowaste, municipal incineration with fly ash extraction	treatment of biowaste, municipal incineration FAE
treatment of coal tar, in industrial furnace 1MW	heat production, coal tar, at industrial furnace 1MW
treatment of coating from waste cathode ray tube display, municipal incineration with fly ash extraction	treatment of coating from waste cathode ray tube display, municipal incineration FAE
treatment of coating from waste cathode ray tube display, municipal waste incineration	treatment of coating from waste cathode ray tube display, municipal incineration
treatment of copper in car shredder residue, municipal incineration with fly ash extraction	treatment of copper in car shredder residue, municipal incineration FAE
treatment of digester sludge, municipal incineration with fly ash extraction	treatment of digester sludge, municipal incineration FAE
treatment of hard coal ash, municipal incineration with fly ash extraction	treatment of hard coal ash, municipal incineration FAE
treatment of lead in car shredder residue, municipal incineration with fly ash extraction	treatment of lead in car shredder residue, municipal incineration FAE
treatment of lignite ash, municipal incineration with fly ash extraction	treatment of lignite ash, municipal incineration FAE
treatment of municipal solid waste, incineration	treatment of municipal solid waste, municipal incineration
treatment of municipal solid waste, municipal incineration with fly ash extraction	treatment of municipal solid waste, municipal incineration FAE
treatment of raw sewage sludge, municipal incineration with fly ash extraction	treatment of raw sewage sludge, municipal incineration FAE
treatment of residue from mechanical treatment, cathode ray tube display, municipal incineration with fly ash extraction	treatment of residue from mechanical treatment, cathode ray tube display, municipal incineration FAE
treatment of residue from mechanical treatment, cathode ray tube display, municipal waste incineration	treatment of residue from mechanical treatment, cathode ray tube display, municipal incineration
treatment of residue from mechanical treatment, desktop computer, municipal incineration with fly ash extraction	treatment of residue from mechanical treatment, desktop computer, municipal incineration FAE
treatment of residue from mechanical treatment, desktop computer, municipal waste incineration	treatment of residue from mechanical treatment, desktop computer, municipal incineration
treatment of residue from mechanical treatment, industrial device, municipal incineration with fly ash extraction	treatment of residue from mechanical treatment, industrial device, municipal incineration FAE
treatment of residue from mechanical treatment, industrial device, municipal waste incineration	treatment of residue from mechanical treatment, industrial device, municipal incineration
treatment of residue from mechanical treatment, IT accessory, municipal incineration with fly ash extraction	treatment of residue from mechanical treatment, IT accessory, municipal incineration FAE
treatment of residue from mechanical treatment, IT accessory, municipal waste incineration	treatment of residue from mechanical treatment, IT accessory, municipal incineration
treatment of residue from mechanical treatment, laptop computer, municipal incineration with fly ash extraction	treatment of residue from mechanical treatment, laptop computer, municipal incineration FAE

treatment of residue from mechanical treatment, laptop computer, municipal waste incineration	treatment of residue from mechanical treatment, laptop computer, municipal incineration
treatment of residue from mechanical treatment, laser printer, municipal incineration with fly ash extraction	treatment of residue from mechanical treatment, laser printer, municipal incineration FAE
treatment of residue from mechanical treatment, laser printer, municipal waste incineration	treatment of residue from mechanical treatment, laser printer, municipal incineration
treatment of residue from mechanical treatment, liquid crystal display, municipal incineration with fly ash extraction	treatment of residue from mechanical treatment, liquid crystal display, municipal incineration FAE
treatment of residue from mechanical treatment, liquid crystal display, municipal waste incineration	treatment of residue from mechanical treatment, liquid crystal display, municipal incineration
treatment of residue from shredder fraction from manual dismantling, municipal incineration with fly ash extraction	treatment of residue from shredder fraction from manual dismantling, municipal incineration FAE
treatment of residue from shredder fraction from manual dismantling, municipal waste incineration	treatment of residue from shredder fraction from manual dismantling, municipal incineration
treatment of scrap aluminium, municipal incineration with fly ash extraction	treatment of scrap aluminium, municipal incineration FAE
treatment of scrap copper, municipal incineration with fly ash extraction	treatment of scrap copper, municipal incineration FAE
treatment of scrap steel, municipal incineration with fly ash extraction	treatment of scrap steel, municipal incineration FAE
treatment of scrap tin sheet, municipal incineration with fly ash extraction	treatment of scrap tin sheet, municipal incineration FAE
treatment of spent anion exchange resin from potable water production, municipal incineration with fly ash extraction	treatment of spent anion exchange resin from potable water production, municipal incineration FAE
treatment of spent cation exchange resin from potable water production, municipal incineration with fly ash extraction	treatment of spent cation exchange resin from potable water production, municipal incineration FAE
treatment of steel in car shredder residue, municipal incineration with fly ash extraction	treatment of steel in car shredder residue, municipal incineration FAE
treatment of used liquid crystal display module, municipal incineration with fly ash extraction	treatment of used liquid crystal display module, municipal incineration FAE
treatment of used liquid crystal display module, municipal waste incineration	treatment of used liquid crystal display module, municipal incineration
treatment of used refrigerant R-12, final disposal	treatment of used refrigerant R12, final disposal
treatment of used refrigerant R-12, venting	treatment of used refrigerant R12, venting
treatment of used refrigerant R-600a, final disposal	treatment of used refrigerant R600a, final disposal
treatment of used refrigerant R-600a, venting	treatment of used refrigerant R600a, venting
treatment of waste bitumen sheet, municipal incineration with fly ash extraction	treatment of waste bitumen sheet, municipal incineration FAE
treatment of waste building wood, chrome preserved, municipal incineration with fly ash extraction	treatment of waste building wood, chrome preserved, municipal incineration FAE
treatment of waste cement-fibre slab, dismantled, municipal incineration with fly ash extraction	treatment of waste cement-fibre slab, dismantled, municipal incineration FAE
treatment of waste cement-fibre slab, municipal incineration	treatment of waste cement-fibre slab, dismantled, municipal incineration
treatment of waste cooking oil, purified, esterification	treatment of used vegetable cooking oil, purified, esterification
treatment of waste emulsion paint on wood, collection for final disposal	treatment of waste emulsion paint, on wood, collection for final disposal
treatment of waste emulsion paint, municipal incineration with fly ash extraction	treatment of waste emulsion paint, municipal incineration FAE

treatment of waste expanded polystyrene, municipal incineration with fly ash extraction	treatment of waste expanded polystyrene, municipal incineration FAE
treatment of waste glass, municipal incineration with fly ash extraction	treatment of waste glass, municipal incineration FAE
treatment of waste graphical paper, municipal incineration with fly ash extraction	treatment of waste graphical paper, municipal incineration FAE
treatment of waste newspaper, municipal incineration with fly ash extraction	treatment of waste newspaper, municipal incineration FAE
treatment of waste packaging paper, municipal incineration with fly ash extraction	treatment of waste packaging paper, municipal incineration FAE
treatment of waste paint, municipal incineration with fly ash extraction	treatment of waste paint, municipal incineration FAE
treatment of waste paperboard, municipal incineration with fly ash extraction	treatment of waste paperboard, municipal incineration FAE
treatment of waste plastic, consumer electronics, municipal incineration with fly ash extraction	treatment of waste plastic, consumer electronics, municipal incineration FAE
treatment of waste plastic, industrial electronics, municipal incineration with fly ash extraction	treatment of waste plastic, industrial electronics, municipal incineration FAE
treatment of waste plastic, mixture, municipal incineration with fly ash extraction	treatment of waste plastic, mixture, municipal incineration FAE
treatment of waste polyethylene terephthalate, municipal incineration with fly ash extraction	treatment of waste polyethylene terephthalate, municipal incineration FAE
treatment of waste polyethylene, municipal incineration with fly ash extraction	treatment of waste polyethylene, municipal incineration FAE
treatment of waste polypropylene, municipal incineration with fly ash extraction	treatment of waste polypropylene, municipal incineration FAE
treatment of waste polystyrene, municipal incineration with fly ash extraction	treatment of waste polystyrene, municipal incineration FAE
treatment of waste polyurethane, municipal incineration with fly ash extraction	treatment of waste polyurethane, municipal incineration FAE
treatment of waste polyvinylchloride, municipal incineration with fly ash extraction	treatment of waste polyvinylchloride, municipal incineration FAE
treatment of waste polyvinylfluoride, municipal incineration with fly ash extraction	treatment of waste polyvinylfluoride, municipal incineration FAE
treatment of waste rubber, unspecified, municipal incineration with fly ash extraction	treatment of waste rubber, unspecified, municipal incineration FAE
treatment of waste sealing sheet, polyethylene, municipal incineration with fly ash extraction	treatment of waste sealing sheet, polyethylene, municipal incineration FAE
treatment of waste sealing sheet, polyvinylchloride, municipal incineration with fly ash extraction	treatment of waste sealing sheet, polyvinylchloride, municipal incineration FAE
treatment of waste textile, soiled, municipal incineration with fly ash extraction	treatment of waste textile, soiled, municipal incineration FAE
treatment of waste vapour barrier, flame-retarded, municipal incineration with fly ash extraction	treatment of waste vapour barrier, flame-retarded, municipal incineration FAE
treatment of waste wire plastic, municipal incineration with fly ash extraction	treatment of waste wire plastic, municipal incineration FAE
treatment of waste wood pole, chrome preserved, municipal incineration with fly ash extraction	treatment of waste wood pole, chrome preserved, municipal incineration FAE
treatment of waste wood, untreated, municipal incineration with fly ash extraction	treatment of waste wood, untreated, municipal incineration FAE
treatment of wood ash mixture, pure, municipal incineration with fly ash extraction	treatment of wood ash mixture, pure, municipal incineration FAE
treatment of zinc in car shredder residue, municipal incineration with fly ash extraction	treatment of zinc in car shredder residue, municipal incineration FAE
triazine-compound production, unspecified	triazine-compound production

trichloromethane production	chloroform production
wheat production	wheat grain production
wheat production, organic	wheat grain production, organic
wheat production, Swiss integrated production, extensive	wheat grain production, Swiss integrated production, extensive
wheat production, Swiss integrated production, intensive	wheat grain production, Swiss integrated production, intensive

2.2 Exchanges

2.2.1 Renamed exchanges

Some intermediate exchanges were renamed for more precision, correction of mistakes, or alignment with elementary exchanges names (**Table 2**).

Table 2. Intermediate exchanges renamed for version 3.10.

Intermediate exchange name in v3.9.1	Intermediate exchange name in v3.10
1,1-difluoroethane, HFC-152a	1,1-difluoroethane
2,3-dimethylbutan	2,3-dimethylbutane
2-cyclopentone	2-cyclopentanone
amine oxide	amine oxides
asbestos, crysotile type	asbestos, chrysotile type
butane-1,4-diol	1,4-butanediol
chromium oxide, flakes	chromium trioxide, flakes
dichloropropene	1,3-dichloropropene
ethylenediamine	ethylene diamine
hydrogen, gaseous	hydrogen, gaseous, low pressure
hydrogen, liquid	hydrogen, gaseous, medium pressure, merchant
iron (III) chloride, without water, in 40% solution state	iron(III) chloride, without water, in 40% solution state
maintenance, tanker for liquid goods other than petroleum and liquefied natural gas	maintenance, tanker, for liquid goods other than petroleum and liquefied natural gas
methane sulfonic acid	methylsulfonic acid
methyl tert-butyl ether	methyl t-butyl ether
ortho-phenylene diamine	o-phenylene diamine
para-phenylene diamine	p-phenylene diamine

Intermediate exchange name in v3.9.1	Intermediate exchange name in v3.10
polylactide, granulate	polylactic acid, granulate
roof tile	clay roof tile
tert-butyl amine	t-butyl amine
triazine-compound, unspecified	triazine-compound
trichloromethane	chloroform
used refrigerant R-12	used refrigerant R12
used refrigerant R-600a	used refrigerant R600a
xylene	xylene, mixed

The list of elementary exchanges was revised and names were changed to increase readability, precision, and overall consistency of names (**Table 3**). There was also some alignment with names of intermediate exchanges.

Table 3. Elementary exchanges renamed for version 3.10.

Elementary exchange name in v3.9.1	Elementary exchange name in v3.10
1,2-Dichlorobenzene	o-Dichlorobenzene
1,3-Dioxolan-2-one	Ethylene carbonate
2,2,4-Trimethyl pentane	2,2,4-Trimethylpentane
2-Amino-3-chloro-1,4-naphthoquinone	Quinoclamine
2-chlorobenzaldehyde	o-Chlorobenzaldehyde
2-Methyl-1-propanol	Isobutanol
2-Methylpentane	Isohexane
2-Propanol	Isopropanol
Acetic acid, trifluoro-	Trifluoroacetic acid
AOX, Adsorbable Organic Halogen	AOX, Adsorbable Organic Halides
Argon-40	Argon
Benzene, chloro-	Monochlorobenzene
Benzene, ethyl-	Ethyl benzene
Benzene, hexachloro-	Hexachlorobenzene
Benzene, pentachloro-	Pentachlorobenzene
Bicyclorpyrone	Bicyclopyrone

Elementary exchange name in v3.9.1	Elementary exchange name in v3.10
Butylcarbamate, iodopropynyl	Iodopropynyl butylcarbamate
Caesium	Caesium I
Calcium	Calcium II
Chloroethylene	Vinyl chloride
Chlorosilane, trimethyl-	Trimethylchlorosilane
Chlortoluron	Chlorotoluron
Coal, hard, unspecified	Coal, hard
Cyhalothrin, gamma-	Gamma-cyhalothrin
Dimethenamid	Dimethenamide
Dipropylamine	Dipropyl amine
Elemental carbon	Carbon
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	1,1,1,2-Tetrafluoroethane
Ethane, 1,1,1-trichloro-, HCFC-140	1,1,1-Trichloroethane
Ethane, 1,1,1-trifluoro-, HFC-143a	1,1,1-Trifluoroethane
Ethane, 1,1,2-trichloro-	1,1,2-Trichloroethane
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	1,1,2-Trichloro-1,2,2-trifluoroethane
Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b	1,1-Dichloro-1-fluoroethane
Ethane, 1,1-difluoro-, HFC-152a	1,1-Difluoroethane
Ethane, 1,2-dichloro-	Ethylene dichloride
Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	1,2-Dichloro-1,1,2,2-tetrafluoroethane
Ethane, 1-chloro-1,1-difluoro-, HCFC-142b	1-Chloro-1,1-difluoroethane
Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123	2,2-Dichloro-1,1,1-trifluoroethane
Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124	2-Chloro-1,1,1,2-tetrafluoroethane
Ethane, chloropentafluoro-, CFC-115	Monochloropentafluoroethane
Ethane, hexachloro-	Hexachloroethane
Ethane, hexafluoro-, HFC-116	Hexafluoroethane
Ethane, pentafluoro-, HFC-125	Pentafluoroethane
Ethyne	Acetylene
Fosetyl-aluminium	Fosetyl-Al
Hexamethyldisilizane	Hexamethyldisilazane
Hydrogen-3, Tritium	Tritium
Manganese-55	Manganese

Elementary exchange name in v3.9.1	Elementary exchange name in v3.10
Methane, chlorodifluoro-, HCFC-22	Chlorodifluoromethane
Methane, chloro-fluoro-, HCFC-31	Chloro-fluoromethane
Methane, chlorotrifluoro-, CFC-13	Chlorotrifluoromethane
Methane, dichloro-, HCC-30	Dichloromethane
Methane, dichlorodifluoro-, CFC-12	Dichlorodifluoromethane
Methane, dichlorofluoro-, HCFC-21	Dichlorofluoromethane
Methane, difluoro-, HFC-32	Difluoromethane
Methane, monochloro-, R-40	Methylchloride
Methane, tetrachloro-, R-10	Carbon tetrachloride
Methane, tetrafluoro-, R-14	Tetrafluoromethane
Methane, trichlorofluoro-, CFC-11	Trichlorofluoromethane
Methane, trifluoro-, HFC-23	Trifluoromethane
Methyl borate	Trimethyl borate
Monophenyltin	Phenyltin
Phenol, 2,4-dichloro	2,4-Dichlorophenol
Phenol, pentachloro-	Pentachlorophenol
Phthalate, butyl-benzyl-	Butyl benzyl phthalate
Phthalate, dibutyl-	Dibutyl phthalate
Phthalate, dimethyl-	Dimethyl phthalate
Phthalate, dioctyl-	Dioctyl phthalate
Prohexadione-calcium	Prohexadione calcium
Propene	Propylene
Propylamine	Propyl amine
Sodium	Sodium I
Sodium sulphate, various forms	Sodium sulfate
Strontium	Strontium II
t-Butylamine	t-Butyl amine
Toluene, 2-chloro	o-Chlorotoluene
Xylene	Xylenes, unspecified

2.2.2 Updated exchanges data

Some of the data for elementary exchanges and intermediate exchanges was updated. This concerns CAS number, formulas, and comments. CAS numbers and formulas were added where missing and removed for exchanges referring to a group of substances with different possible formulas. Formulas for isotopes now include the mass number (number of nucleons), for example, “234U” for “Uranium-234”. Furthermore, elemental contents of exchanges with a formula were updated based on these formulas to ensure completeness and consistent calculation of elemental contents. “Manganese-55” is a stable isotope and hence the name for emissions to water was changed to “Manganese” and the unit from kBq to kg. The exchange is not used in the database.

2.2.3 Deleted and replaced elementary exchanges

Several elementary exchanges (EEs) were deleted as they either should not be used. EEs for extraction of mineral resources from ground (or in a few cases water) included the ore composition in older versions (for example, “Silver, Ag 1.5E-4%, Au 6.8E-4%, in ore”), but the flow refers to silver. Hence, the flow given in the example should only be “Silver” (and the ore is modelled as the single elements plus gangue according to the given composition). All EEs named the old way were deleted from the master data (and can be replaced by those having only the element as name if still existing in data projects). They had already been replaced in the datasets for version 3.6 and have therefore not been in use since that version.

Emissions to the sub-compartment “lower stratosphere + upper troposphere”, which is the flight altitude compartment, are meant for emissions from air transport. However, several EEs, which do not belong to an aircraft emission profile were available. These were deleted. Furthermore, EEs in datasets using wrongly this sub-compartment were replaced with the EEs with the “unspecified” sub-compartment. Affected datasets are shown in **Table 4**.

Table 4. Names and geographies of datasets affected by the replacement of emissions to the “lower stratosphere + upper troposphere” compartment.

Name	Geographies
dolomite production	GLO; RER
electricity production, hydro, reservoir, alpine region	PE
fava bean production	CA-AB; CA-MB; CA-SK; GLO
fishmeal and fish oil production, 63-65% protein, from fish residues	GLO; PE
fishmeal and fish oil production, 63-65% protein, from fresh anchovy	GLO; PE
fishmeal and fish oil production, 63-65% protein, from fresh anchovy and fish residues	GLO; PE
fishmeal and fish oil production, 65-67% protein	GLO; PE
lentil production	CA-AB; CA-SK; GLO
mango production, conditioned, heat treatment	BR; GLO
mango production, conditioned, wax treatment	BR; GLO
navy bean production	CA-MB; CA-ON; GLO
palm date production	GLO
palm date production, organic	GLO
phosphate rock beneficiation	GLO

phosphate rock beneficiation	RER
pinto bean production	CA-AB; CA-MB; GLO
protein pea production	CA-AB; CA-MB; CA-SK
red kidney bean production	CA-MB; CA-ON; GLO
seawater reverse osmosis module production, 8-inch spiral wound, baseline	GLO
seawater reverse osmosis module production, 8-inch spiral wound, enhanced	GLO
seed-cotton production, conventional	GLO
venting of carbon dioxide, in chemical industry	GLO
water production, deionised	CH; Europe without Switzerland; GLO

Another mistake in datasets was the wrong use of “long-term” sub-compartments (emissions to air and groundwater). Here, “air | low population density, long-term” was replaced by “air | non-urban air or from high stacks” and “water | ground, long-term” was replaced by “water | ground”. There was no need to change anything in the master data. Affected datasets are shown in Table 5.

Table 5. **Names and geographies of datasets affected by the replacement of emissions to the “long-term” compartments.**

Name	Geographies
aluminium production, primary, ingot	CA; CN; GLO; IAI Area, Africa; IAI Area, Asia, without China and GCC; IAI Area, EU27 & EFTA; IAI Area, Gulf Cooperation Council; IAI Area, Russia & RER w/o EU27 & EFTA; IAI Area, South America; UN-OCEANIA
o-chlorobenzaldehyde production	GLO; RER

Finally, there were some redundant, unspecific, or wrong EEs, which were replaced by equivalent, more specific, and correct EEs (**Table 6**), also in datasets. The replaced EEs were deleted. For “Salt water (obsolete)” there is no replacement as there is no saltwater flow in the ecoinvent EE list. All deletions and replacements of EEs in the master data are listed in the “EE Deletions” sheet in the Change Report Annex.

Table 6. Replaced (and deleted) elementary exchanges.

Replaced exchange	Replacing exchange
2,4-D amines	2,4-D dimethylamine salt
Chromium IV	Chromium VI
Cyclohexane (for all cycloalkanes)	Hydrocarbons, aliphatic, alkanes, cyclic
Elemental carbon	Carbon
Fresh water (obsolete)	Water
Pyrethrins	Pyrethrum

Salt water (obsolete)	
Sodium	Sodium I

2.3 Impact assessment methods

The main task in implementing impact assessment methods is mapping the ecoinvent elementary exchanges list to method elementary exchanges lists. This includes assumptions concerning many aspects, for example, flow names and compartment/sub-compartment mapping choices. These assumptions are documented in the LCIA implementation report (Sonderegger & Stoikou, 2023). The result of the implementation is available in a series of spreadsheets, showing the explicit mapping between the nomenclature of the database and each LCIA method.[1] This section discusses some changes made to these implementation files and – to start with – added and deleted methods.

2.3.1 New and deleted methods

The following methods were introduced with v3.10:

- EN15804 EPD PCR extension for GWP (introduced as impact category in EF v3.X EN15804 methods, see section 2.3.2)
- IMPACT World+ v2.0.1, footprint version
- Inventory results and indicators
- USEtox v2.13

The addition of methods allowed to delete some old methods. These are the following:

- EDIP 2003
- IMPACT 2002+ (Endpoint)
- IMPACT 2002+ (Midpoint)
- selected LCI results
- selected LCI results, additional
- USEtox

"IMPACT World+ v2.0.1, footprint version" and "USEtox v2.13" replace "IMPACT 2002+" and "USEtox", respectively. "Inventory results and indicators" builds on selected LCI methods and integrates some of the waste indicators used in "EDIP 2003".

2.3.2 Changes in indicator and indicator unit names

A new indicator for the "climate change" impact category was introduced to the EF v3.x EN15804 methods. The EPD product category rules for construction products PCR 2019:14 (EPD, 2023) includes minor modifications of the GWP assessment for its GWP-GHG impact

[1] https://github.com/ecoinvent/lcia

category. We have added this impact category as “climate change: GHG (EPD PCR)” to the EF v3.x EN15804 implementations as shown in **Table 7**. The details are described in the LCIA implementation report (Sonderegger & Stoikou, 2023).

Table 7. Addition of the EPD Product Category Rule climate change assessment in EF v3.x EN15804 methods.

Method	Category	Indicator
EF v3.0 EN15804	climate change: GHG (EPD PCR)	global warming potential (GWP100)
EF v3.1 EN15804	climate change: GHG (EPD PCR)	global warming potential (GWP100)

The indicator unit name for “user deprivation potential” in EF v3.x methods was changed to be consistent with other indicator unit names (**Table 8**).

Table 8. Unit name change for “user deprivation potential” in EF v3.x methods.

Method	Category	indicator name 3.10	Unit in 3.9.1	Unit in 3.10
EF v3.0	water use	user deprivation potential (deprivation-weighted water consumption)	m3 world eq. deprived	m3 world Eq deprived
EF v3.0 no LT	water use no LT	user deprivation potential (deprivation-weighted water consumption) no LT	m3 world eq. deprived	m3 world Eq deprived
EF v3.1	water use	user deprivation potential (deprivation-weighted water consumption)	m3 world eq. deprived	m3 world Eq deprived
EF v3.1 no LT	water use no LT	user deprivation potential (deprivation-weighted water consumption) no LT	m3 world eq. deprived	m3 world Eq deprived
EF v3.0 EN15804	water use	user deprivation potential (deprivation-weighted water consumption)	m3 world eq. deprived	m3 world Eq deprived
EF v3.1 EN15804	water use	user deprivation potential (deprivation-weighted water consumption)	m3 world eq. deprived	m3 world Eq deprived

2.3.3 Changes in characterization factors (CFs)

Details for changes in characterization factors (CFs) can be found in the Change Report Annex.

2.3.3.1 CML v4.8 2016

The CF for Alpha-cypermethrin was deleted as it was based on using Cypermethrin as proxy, which leads to an overestimation.

2.3.3.2 EF v3.0 and EF v3.0 EN15804

CFs for emissions to surface and ground-water were updated for Acrylate, Paraffins, and Silicon due to an improved compartment/sub-compartment mapping. Furthermore, CFs for Gamma-cyhalothrin were updated due to a change in proxy mapping for Cyhalothrins (see Sonderegger & Stoikou 2023 for details). Finally, some CFs for the renamed “Carbon tetrachloride” (previously “Methane, tetrachloro-, R-10”) were deleted. This is because EF v3.0 has different flows (“Carbon tetrachloride”, “CFC-10”) that could be mapped to Carbon tetrachloride with different CFs. We chose to go with the name match, which meant a new mapping. However, there seems to be an issue with EF CFs as emissions to water should have toxicity effects, which were seemingly overestimated when mapped to CFC-10 comparing it with values for USEtox and TRACI, which use the same unit (Comparative Toxic Unit).

2.3.3.3 EF v3.1 and EF v3.1 EN15804

CFs for Gamma-cyhalothrin were updated due to a change in proxy mapping for Cyhalothrins (see Sonderegger & Stoikou 2023 for details).

2.3.3.4 EPS 2020d

The CFs for climate change had wrong signs for the flow “Carbon dioxide, to soil or biomass stock” (should be negative as it is a carbon uptake by soils). This was corrected.

2.3.3.5 ReCiPe 2016 endpoint methods

The CFs for climate change had wrong signs for the flow “Carbon dioxide, to soil or biomass stock” (should be negative as it is a carbon uptake by soils). Furthermore, the values for the Individualist (I) perspective were wrong. For the Egalitarian (E) and the Hierarchist (H) perspectives, water flows were wrongly characterized for the total impacts on natural resources. Furthermore, there were some wrong CF values for water flows for the Hierarchist perspective. All these mistakes were corrected.

2.3.4 Characterization factors of new elementary exchanges

Some elementary exchanges were added for v3.10 and, alongside this, CFs to existing methods. This includes new substances (and other flows) and new compartments/sub-compartments for existing substances (and other flows). Some of these are not used in the database and hence do not affect LCIA scores. The methods and impact categories affected by new elementary exchanges are listed in **Table 9**.

Table 9. Methods and impact categories affected by new elementary exchanges.

Method	Impact Category
CML v4.8 2016	ecotoxicity: freshwater
CML v4.8 2016	ecotoxicity: marine
CML v4.8 2016	ecotoxicity: terrestrial
CML v4.8 2016	eutrophication

CML v4.8 2016	human toxicity
Ecological Scarcity 2021	emissions to air
Ecological Scarcity 2021	emissions to water
Ecological Scarcity 2021	total
EF v3.0 / v3.1	ecotoxicity: freshwater
EF v3.0 / v3.1	ecotoxicity: freshwater, inorganics
EF v3.0 / v3.1	ecotoxicity: freshwater, organics
EF v3.0 / v3.1	human toxicity: carcinogenic
EF v3.0 / v3.1	human toxicity: carcinogenic, organics
EF v3.0 / v3.1	human toxicity: non-carcinogenic
EF v3.0 / v3.1	human toxicity: non-carcinogenic, inorganics
EF v3.0 / v3.1	human toxicity: non-carcinogenic, organics
EF v3.0 / v3.1 EN15804	ecotoxicity: freshwater
EF v3.0 / v3.1 EN15804	human toxicity: carcinogenic
EF v3.0 / v3.1 EN15804	human toxicity: non-carcinogenic
EPS 2020d	emissions to soil
EPS 2020d	total
ReCiPe 2016 v1.03, endpoint	ecosystem quality
ReCiPe 2016 v1.03, endpoint	human health
ReCiPe 2016 v1.03, endpoint	total: ecosystem quality
ReCiPe 2016 v1.03, endpoint	total: human health
ReCiPe 2016 v1.03, midpoint	ecotoxicity: freshwater
ReCiPe 2016 v1.03, midpoint	ecotoxicity: marine
ReCiPe 2016 v1.03, midpoint	ecotoxicity: terrestrial
ReCiPe 2016 v1.03, midpoint	human toxicity: carcinogenic
ReCiPe 2016 v1.03, midpoint	human toxicity: non-carcinogenic
TRACI v2.1	ecotoxicity: freshwater
TRACI v2.1	eutrophication
TRACI v2.1	human toxicity: carcinogenic
TRACI v2.1	human toxicity: non-carcinogenic
TRACI v2.1	photochemical oxidant formation

2.4 Changes in price

Changes in price affect the LCIA scores of the activities when economic allocation is used. Several prices of products have been updated for version 3.10. The list of products for which the price was updated can be found in Annex 1: Products with updated prices.

2.5 Changes in geographies

In version 3.10 the geographical pipeline, provided as free and open source software at https://github.com/ecoinvent/ecoinvent-topology, was revised. The complete data and geographies report is available at https://geography.ecoinvent.org.

The source GIS data was updated to Natural Earth version 5.1.1, and the way we construct regions was changed to a union of all the provinces within a country. This change was necessary because there were sometimes small differences between the Natural Earth country and province border definitions.

Some small updates were included to reflect the changing world. In general, ecoinvent follows the ISO country names. So “Turkey” was changed “Türkiye”, and ”Europe, without Russia and Turkey” to “Europe, without Russia and Türkiye”. The Indian states of “Dadra and Nagar Haveli” and “Daman and Diu” were merged to “Dadra and Nagar Haveli and Daman and Diu”, and “Orissa” was renamed to “Odisha”.

In the USA, the electricity system operators FRCC and SPP were dissolved; FRCC (Florida) was taken over by SERC, while SPP was split between other ISOs. See https://github.com/ecoinvent/nerc-regions for details.

Chinese geographies related to electricity transmission were split into multiple subgrids, as shown in **Figure 1**.

Figure 1. Electricity subgrids in China, as modelled in ecoinvent.

The short names for Australia were updated to follow ISO guidelines, and the modelling for Australia was redone to include all states and territories. “Australia” is now all states and internal territories, and “Australia, including overseas territories” includes overseas territories as well.

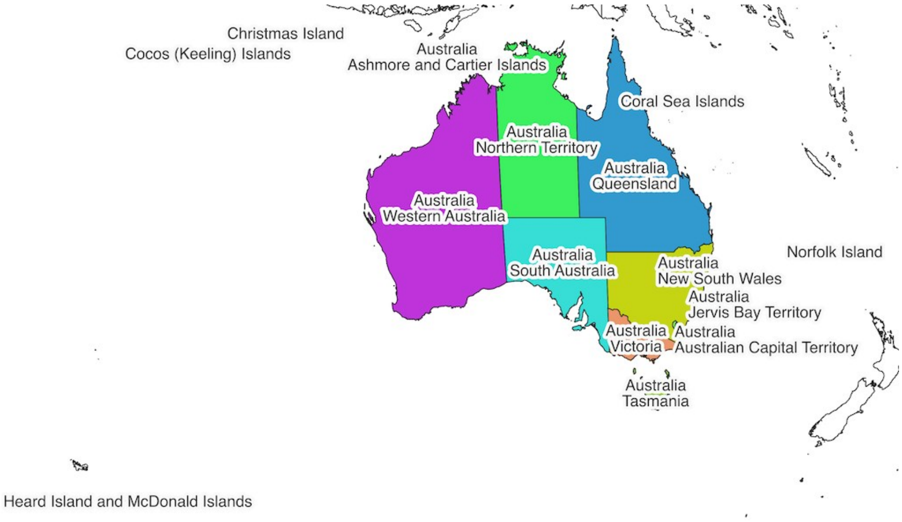

Figure 2. Map showing all states and territories that are part of the geography “Australia, including overseas territories”.

2.6 New and updated classifications for intermediate exchanges

2.6.1 HS 2017 (Harmonized Systems)

For v3.10 of the ecoinvent database, a new classification system for intermediate exchanges is introduced next to the existing CPC (Central Product Classification). The HS (Harmonized System) classification system 2017 Edition was added to every intermediate exchange for which a suitable HS code was available. Other than the CPC classification system, which covers all possible products, and which is compulsory for every intermediate exchange in the ecoinvent database, the HS classification system does not cover every possible product. Generally, most infrastructure and service intermediate exchanges were not classified in the HS system. Consequently, around 70% of all intermediate exchanges received an HS code.

The complete implementation of the HS 2017 classification system as well as newly mapped codes to the intermediate exchanges are included in the Master Data for v3.10.

2.6.2 CPC (Central Product Classification)

In the process of classifying intermediate exchanges for HS 2017 (Section 2.6.1) and recent mapping efforts many CPC codes have been updated. The CPC classification system is structured into codes ranging from one to five levels (level five being the most precise classification). Each level represents a more precise description of a product category. It was aimed to update all CPC codes to a level of at least four digits, however, due to the general nature of some exchanges, this was not entirely possible. All in all, around 900 CPC codes were updated or corrected for v3.10.

3 Fuels

3.1 Crude petroleum oil and natural gas

3.1.1 Overview of updates

An extensive overhaul of the supply of crude petroleum oil and natural gas was undertaken for the release of version 3.9.1 of the ecoinvent database, released in 2022. The updates in this sector for version 3.10 build on the same modelling approach, with the goal to expand geographical coverage of production and supply for the most recent year (2021), based on the most recent statistics available at the time of preparation. A total of 41 countries with oil and gas extraction are covered in version 3.10, representing about 96% of the global production of petroleum and over 98% of natural gas output in 2021. Five new countries with exports of LNG were added for v3.10, and the resulting set of 14 LNG-producing countries were responsible for over 93% of LNG exported globally in 2021 (BP, 2022).

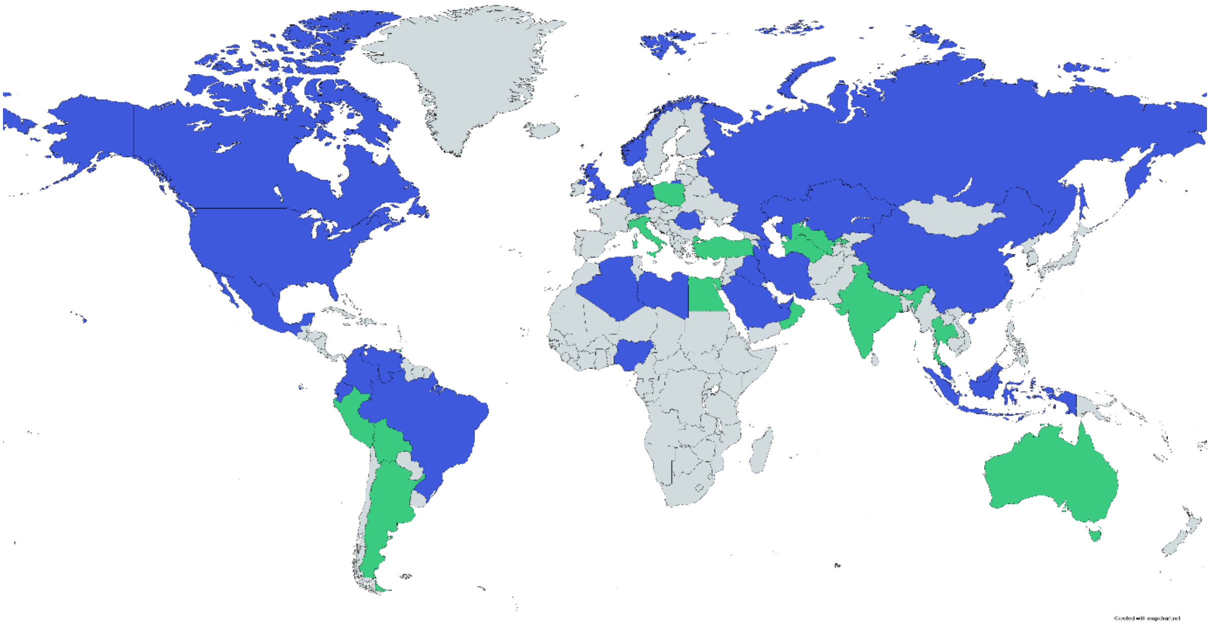

Figure 3. Geographical coverage of crude petroleum oil and natural gas production in the ecoinvent database version 3.10. New countries of production, introduced with v3.10, are indicated in green.

New or updated natural gas supplies (at high pressure) are provided for 57 countries (**Figure 4**), representing 93% of global gas consumption, based on the situation in 2021. Through the addition of important gas-exporting nations like Australia, Oman, or Turkmenistan, the modelled gas imports to Japan, South Korea, and China reflects 89%, 98%, and 92%, respectively, of total imports to these countries in 2021. Consumption mixes for local distribution of natural gas (i.e., at low pressure) are provided for a total of fifteen countries, located in Asia (China, Japan, and South Korea), Europe (Belgium, France, Germany, Italy, the Netherlands, Spain, Switzerland, Turkey, and the United Kingdom) and North America (Canada, Mexico, and the USA) with version 3.10.

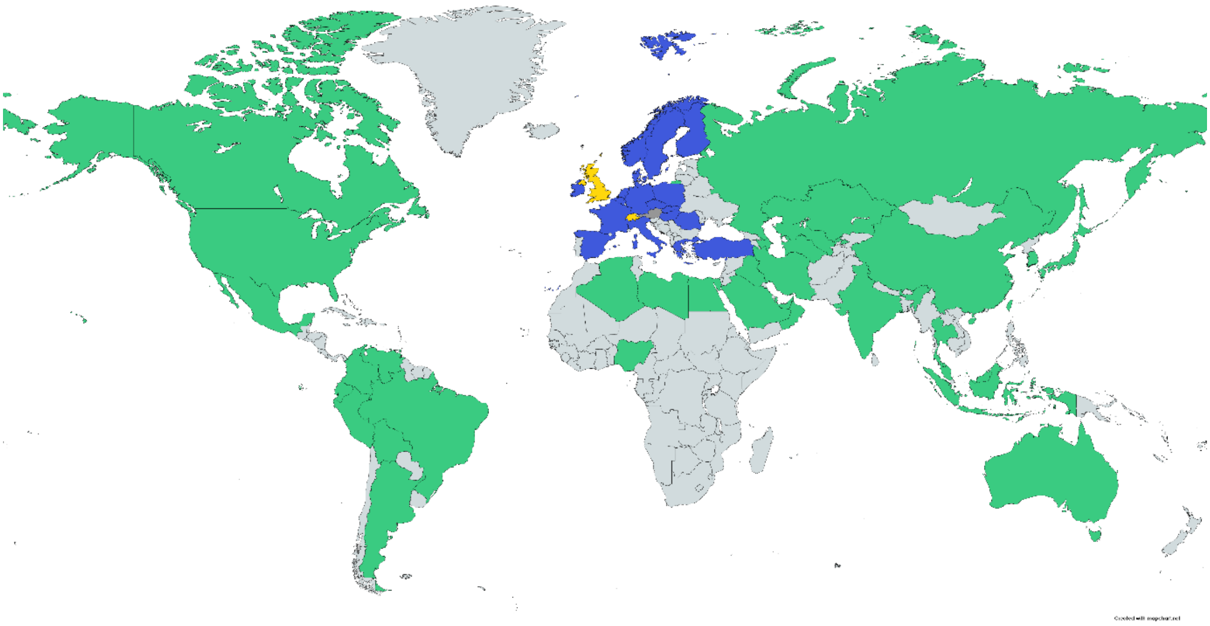

Figure 4. Country-specific supply mixes for natural gas (market for natural gas, high pressure) provided in v3.10. Data sources: BP 2022 (green); EuroStat (blue); other (national statistics; yellow).

3.1.2 Extraction of crude petroleum oil and natural gas

The new data on extraction (i.e., production) of crude petroleum oil and natural gas in ecoinvent version 3.10 increased the geographical coverage to 41 countries, up from 27 in 3.9.1, as shown in **Table 10**. The underlying data sources and inventory modelling are described in (Meili, Jungbluth, & Bussa, 2023a). Following the approach introduced with the update for version 3.9.1, the country-specific production activities were created using a common approach, relying extensively on global data sources to ensure a high degree of consistency between the geographies covered. As a result, the extraction of crude petroleum oil and natural gas is modelled as average combined (i.e., associated) production of oil and gas, only distinguishing between offshore and onshore operations, for each country.

Table 10. New and updated datasets for petroleum and natural gas production. In the column v3.10, "N" stands for "New Activity" and "U" stands for "Updated Activity".

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
petroleum and gas production, offshore	AR; AU; EG; IN; IT; PE; PL; TH; TM; TR; TT	2021-2023	natural gas, high pressure; petroleum	m^3; kg	N
petroleum and gas production, offshore	AE; AZ; BR; CA; CN; CO; DE; EC; GB; ID; IR; KW; KZ; LY; MX; MY; NG; NL; NO; QA; RO; RU; SA; US; VE	2021-2023	natural gas, high pressure; petroleum	m^3; kg	U
petroleum and gas production, onshore	AR; AU; BO; EG; IN; IT; OM; PE; PL; TH; TM; TR; TT; UZ	2021-2023	natural gas, high pressure; petroleum	m^3; kg	N

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
petroleum and gas production, onshore	AE; AZ; BR; CA; CN; CO; DE; DZ; EC; GB; ID; IQ; IR; KW; KZ; LY; MX; MY; NG; NL; QA; RO; RU; SA; US; VE	2021-2023	natural gas, high pressure; petroleum	m^3; kg	U

The main aspects considered for regionalisation of the extraction activities include emissions of methane (from gas venting and fugitive emission sources) and gas flaring, energy requirements, production data, and infrastructure inputs (borewell and pipeline distances). For this update, (Meili, Jungbluth, & Bussa, 2023a) relied on the most recent versions of the main data sources available at the time of preparation, including (BP, 2022), (IEA, 2022), (IOGP, 2022), and (The World Bank, 2023).

The default physical properties of petroleum and natural gas (gaseous and liquefied) were updated for version 3.9.1 in 2022, and remain unchanged for the release of 3.10.[2] In contrast, the price properties of these products were updated based on the information available from United Nations Commodity Trade Statistics Database (UN Comtrade). Averages for each product were derived from the prices of imports and exports into the five main economies (CN, EU, IN, JP, and the US), considering a three-year time period (2019-2021). (**Table 11**) The price properties do not affect the allocation of the combined production activities (offshore/onshore) for petroleum and natural gas. The general allocation procedure applied for the combined production activities is described in section 2.2 of (Meili, Jungbluth, & Bussa, 2023a, pp. 4-5).

Table 11. Updated prices for petroleum and natural gas in version 3.10.

Product	Price, old in EUR2005	Price, v3.10 in EUR2005	UN Comtrade category used for update
natural gas, high pressure	0.166	0.167	271121 - Natural gas in gaseous state
natural gas, liquefied	0.27	0.233	271111 - Natural gas, liquified
natural gas, low pressure	0.205	0.167	271121 - Natural gas in gaseous state
petroleum	0.192	0.298	270900 - Oils; petroleum oils and oils obtained from bituminous minerals, crude

The main changes in terms of inventory modelling for oil and gas production in version 3.10 concerns the water balance and discharge of produced water and the required borewell

[2] The net heating value for petroleum stated in the general comment of the markets activities for petroleum is incorrect, the correct value is 43.4 MJ/kg.

infrastructure input (per oil equivalent). Both aspects are described in detail in (Meili, Jungbluth, & Bussa, 2023a), in sections 10.1 and 6.1, respectively.

For the update for v3.10, (Meili, Jungbluth, & Bussa, 2023a) used regional factors published by (IOGP, 2022) for freshwater use intensity as well as for reinjected produced water and the share of reinjected water on overall amount of produced water to calculate water discharge per unit of oil equivalent produced. Three-year averages for 2019-2021 were applied in both cases. It should be noted, however, that the regional coverage (as share of reported production) in the IOGP statistics varies substantially between regions (IOGP, 2022, p. 7). The lowest coverages are observed for Russia & Central Asia (10% of regional production), Middle East (12%), and North America (14%). Alternative data sources and/or modelling approaches should be considered for future updates to ensure representativeness for the full scope of production in these regions. As discussed in section 10.1.4 in (Meili, Jungbluth, & Bussa, 2023a, pp. 59-60), the calculated amount of water produced exceed the freshwater input accounted for in most regions. Nevertheless, the authors assume a neutral water balance in terms of contribution to freshwater availability. This due to concerns about the completeness and representativeness of the available information available on water use in combination with the high uncertainty in terms of the quality of discharged water.

3.1.3 Long-distance transport and supply of crude petroleum oil

The supply mixes for crude petroleum oil in Switzerland, Europe without Switzerland, and the Region of North America (RNA), introduced with v3.9.1, were updated to reflect the trade situation in 2021. The update for v3.10 also introduces new market activities with regional supply mixes for Brazil (BR), Colombia (CO), India (IN), Peru (PE), and South Africa (ZA). Datasets for petroleum refinery operation in these five countries had been created as part of the first phase of the *Sustainable Recycling Industries (SRI)* project (Fehrenbach H., 2018). A summary of new and updated market activities for petroleum is provided in **Table 12**.

The inventory modelling of the long-distance transport (import) and supply mixes is described in (Meili, Jungbluth, & Bussa, 2023b). The underlying data source for this analysis was primarily global energy statistics from BP (2022). To avoid geographical overlaps in the implementation for the ecoinvent database, the global supply situation had to be converted into the corresponding market shares for the Rest-of-the-World (RoW; i.e., GLO without RER, RNA, and the five SRI countries) geography. The RoW mix was derived from the information in (Meili, Jungbluth, & Bussa, 2023b) as the difference between supply to the global geography and the sum of the region-specific markets.

Table 12. New and updated datasets for markets for petroleum. In the column v3.10, “N” stands for “New Activity” and “U” stands for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
market for petroleum	BR; CO; IN; PE; ZA	2021-2023	petroleum	kg	N
market for petroleum	CH; Europe without Switzerland; GLO; RNA	2021-2023	petroleum	kg	U

3.1.4 Long-distance transport and regional distribution of natural gas

The inventory modelling of the long-distance transport (import) and supply mixes for natural gas is described in (Bussa, Jungbluth, & Meili, 2023). This update largely follows the modelling approach introduced with version 3.9.1 in 2022. The focus of the sub-sections below is placed on highlighting any relevant differences between the versions.

3.1.4.1 Internal energy from gas: natural gas, burned in gas turbine

Internal energy supply, provided by combustion of the natural gas during transmission and distribution, is modelled with the activity 'natural gas, burned in gas turbine'. This activity is provided both for the supplying (exporting) and demanding (importing) nations in (Bussa, Jungbluth, & Meili, 2023). To reduce complexity, only one dataset is created per country (**Table 13**). For countries with indigenous production and significant imports, this means that a decision has be made as to whether to link the input of natural gas to domestic supply or the consumption mix. Consumption mixes were selected in cases where the net import exceeded (gross) indigenous production in 2021, based on the information available in (BP, 2022).

The activity 'sweet gas, burned in gas turbine', also listed in **Table 13**, is not used in the updated modelling of petroleum and gas production but this dataset is kept, enabling users to utilize it for own modelling. The update of this activity for v3.10 only introduced an input of oxygen (in air) for a better mass balance of the combustion process.

Table 13. New and updated datasets for natural gas, burned in gas turbine. In the column v3.10, "N" stands for "New Activity" and "U" stands for "Updated Activity".

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas, burned in gas turbine	AR; AU; BO; EG; IN; JP; KR; OM; PE; PL; RER; TH; TM; TT; TW; UZ	2021-2023	natural gas, burned in gas turbine	MJ	N
natural gas, burned in gas turbine	AE; AZ; BR; CA; CO; DZ; EC; ID; IQ; IR; KW; KZ; LY; MY; NG; QA; RU; SA; US; VE	2021-2023	natural gas, burned in gas turbine	MJ	U
natural gas, burned in gas turbine	BE; CH; CN; DE; ES; FR; GB; IT; MX; NL; NO; RO; TR	2021-2023	natural gas, burned in gas turbine	MJ	U
natural gas, burned in gas turbine	GLO	2021-2023	natural gas, burned in gas turbine	MJ	U
sweet gas, burned in gas turbine	GLO	1991-2019	sweet gas, burned in gas turbine	MJ	U

3.1.4.2 Liquefied natural gas (LNG) supply

Through the addition of Australia (AU), Egypt (EG), Oman (OM), Peru (PE), and Trinidad and Tobago (TT), the update for version 3.10 increased the number of countries exporting liquefied natural gas (LNG) from nine in v3.9.1 to 14 in the ecoinvent database (**Table 14**). These countries combined represented over 93% of LNG exported globally in 2021 (BP, 2022).

Table 14. New and updated datasets for production of liquefied natural gas (LNG). In the column v3.10, “N” for “New Activity” and “U” for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas production, liquefied	AU; EG; OM; PE; TT	2021-2023	natural gas, liquefied	m^3	N
natural gas production, liquefied	AE; DZ; ID; MY; NG; NO; QA; RU; US	2021-2023	natural gas, liquefied	m^3	U

The geographical scope of import (**Table 15**) and evaporation (**Table 16**) of LNG was revised compared to v3.9.1, from regional (RER or RNA) to country-specific activities to better reflect the transport distances between the points of supply and demand.

Table 15. Changes for datasets related to the import of liquefied natural gas (LNG). In the column v3.10, “D” stands for “Deleted”, “N” for “New Activity”, and “U” for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas, liquefied, import from AE	CN; JP; KR	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from AE	GLO	2021-2023	natural gas, liquefied	m^3	U
natural gas, liquefied, import from AU	CN; GLO; JP; KR	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from DZ	Europe without Switzerland; RNA	2021-2023	natural gas, liquefied	m^3	D
natural gas, liquefied, import from DZ	BE; CN; ES; FR; GB; IT; NL; RER; TR	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from DZ	GLO	2021-2023	natural gas, liquefied	m^3	U
natural gas, liquefied, import from EG	BE; CN; ES; GLO; IT; JP; KR; RER; TR	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from ID	RNA	2021-2023	natural gas, liquefied	m^3	D
natural gas, liquefied, import from ID	CN; JP; KR; MX	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from ID	GLO	2021-2023	natural gas, liquefied	m^3	U
natural gas, liquefied, import from MY	CN; JP; KR	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from MY	GLO	2021-2023	natural gas, liquefied	m^3	U
natural gas, liquefied, import from NG	Europe without Switzerland; RNA	2021-2023	natural gas, liquefied	m^3	D

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas, liquefied, import from NG	CN; ES; FR; GB; IT; JP; KR; NL; RER; TR	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from NG	GLO	2021-2023	natural gas, liquefied	m^3	U
natural gas, liquefied, import from NO	Europe without Switzerland	2021-2023	natural gas, liquefied	m^3	D
natural gas, liquefied, import from NO	RER	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from NO	GLO	2021-2023	natural gas, liquefied	m^3	U
natural gas, liquefied, import from OM	CN; GLO; JP; KR	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from PE	CA; CN; ES; GB; GLO; JP; KR; NL; RER	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from QA	Europe without Switzerland	2021-2023	natural gas, liquefied	m^3	D
natural gas, liquefied, import from QA	BE; CN; ES; FR; GB; IT; JP; KR; NL; RER; TR	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from QA	GLO	2021-2023	natural gas, liquefied	m^3	U
natural gas, liquefied, import from RU	Europe without Switzerland	2021-2023	natural gas, liquefied	m^3	D
natural gas, liquefied, import from RU	BE; CN; ES; FR; GB; JP; KR; NL; RER	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from RU	GLO	2021-2023	natural gas, liquefied	m^3	U
natural gas, liquefied, import from TT	CA; CN; ES; GB; GLO; KR; MX; NL; RER; TR; US	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from US	Europe without Switzerland	2021-2023	natural gas, liquefied	m^3	D
natural gas, liquefied, import from US	BE; CN; ES; FR; GB; IT; JP; KR; MX; NL; RER; TR	2021-2023	natural gas, liquefied	m^3	N
natural gas, liquefied, import from US	CA; GLO	2021-2023	natural gas, liquefied	m^3	U

Table 16. Changes for datasets related to the evaporation of imported liquefied natural gas (LNG). In the column v3.10, “D” stands for “Deleted”, “N” for “New Activity”, and “U” for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
evaporation of natural gas	BR	2018-2021	natural gas, liquefied	m^3	D
evaporation of natural gas	JP	2000-2005	natural gas, liquefied	m^3	D
evaporation of natural gas, import from AE	CN; JP; KR	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from AE	GLO	2021-2023	natural gas, liquefied	m^3	U

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
evaporation of natural gas, import from AU	CN; GLO; JP; KR	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from DZ	Europe without Switzerland	2000-2022	natural gas, liquefied	m^3	D
evaporation of natural gas, import from DZ	BE; CN; ES; FR; GB; IT; NL; RER; TR	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from DZ	GLO	2021-2023	natural gas, liquefied	m^3	U
evaporation of natural gas, import from EG	BE; CN; ES; GLO; IT; JP; KR; RER; TR	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from ID	RNA	2000-2022	natural gas, liquefied	m^3	D
evaporation of natural gas, import from ID	CN; JP; KR; MX	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from ID	GLO	2021-2023	natural gas, liquefied	m^3	U
evaporation of natural gas, import from MY	CN; JP; KR	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from MY	GLO	2021-2023	natural gas, liquefied	m^3	U
evaporation of natural gas, import from NG	Europe without Switzerland; RNA	2000-2022	natural gas, liquefied	m^3	D
evaporation of natural gas, import from NG	CN; ES; FR; GB; IT; JP; KR; NL; RER; TR	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from NG	GLO	2021-2023	natural gas, liquefied	m^3	U
evaporation of natural gas, import from NO	Europe without Switzerland	2000-2022	natural gas, liquefied	m^3	D
evaporation of natural gas, import from NO	RER	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from NO	GLO	2021-2023	natural gas, liquefied	m^3	U
evaporation of natural gas, import from OM	CN; GLO; JP; KR	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from PE	CA; CN; ES; GB; GLO; JP; KR; NL; RER	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from QA	Europe without Switzerland	2000-2022	natural gas, liquefied	m^3	D
evaporation of natural gas, import from QA	BE; CN; ES; FR; GB; IT; JP; KR; NL; RER; TR	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from QA	GLO	2021-2023	natural gas, liquefied	m^3	U
evaporation of natural gas, import from RU	Europe without Switzerland	2000-2022	natural gas, liquefied	m^3	D
evaporation of natural gas, import from RU	BE; CN; ES; FR; GB; JP; KR; NL; RER	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from RU	GLO	2021-2023	natural gas, liquefied	m^3	U
evaporation of natural gas, import from TT	CA; CN; ES; GB; GLO; KR; MX; NL; RER; TR; US	2021-2023	natural gas, liquefied	m^3	N
evaporation of natural gas, import from US	Europe without Switzerland	2000-2022	natural gas, liquefied	m^3	D
evaporation of natural gas, import from US	BE; CN; ES; FR; GB; IT; JP; KR; MX; NL; RER; TR	2021-2023	natural gas, liquefied	m^3	N

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
evaporation of natural gas, import from US	CA; GLO	2021-2023	natural gas, liquefied	m^3	U

3.1.4.3 Long-distance pipeline transport of natural gas

An overview of changes to datasets for long-distance transport of natural gas in pipelines is provided in **Table 17**.

Table 17. Changes to datasets for long-distance pipeline transport of natural gas. In the column v3.10, "D" stands for "Deleted", "N" for "New Activity", and "U" for "Updated Activity".

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
transport, pipeline, long distance, natural gas	RU	2001-2012	transport, pipeline, long distance, natural gas	metric ton*km	D
transport, pipeline, offshore, long distance, natural gas	GLO	2000-2012	transport, pipeline, offshore, long distance, natural gas	metric ton*km	D
transport, pipeline, offshore, long distance, natural gas	DZ; GB; IR; LY; MY; NL; NO; QA; RU; US	2021-2023	transport, pipeline, offshore, long distance, natural gas	metric ton*km	U
transport, pipeline, onshore, long distance, natural gas	GLO	2000-2012	transport, pipeline, onshore, long distance, natural gas	metric ton*km	D
transport, pipeline, onshore, long distance, natural gas	BO; TM; UZ	2021-2023	transport, pipeline, onshore, long distance, natural gas	metric ton*km	N
transport, pipeline, onshore, long distance, natural gas	AE; AZ; BR; CA; CN; CO; DE; DZ; EC; GB; ID; IQ; IR; KW; KZ; MX; MY; NG; NL; NO; QA; RO; RU; SA; US; VE	2021-2023	transport, pipeline, onshore, long distance, natural gas	metric ton*km	U

3.1.4.4 Import and regional distribution of natural gas

The market activities for natural gas in the ecoinvent database are supplied by indigenous production (where relevant) and/or over import activities. For the former case, the activity 'natural gas, high pressure, domestic supply with seasonal storage' sits between production and the market, to account for energy requirements and losses from seasonal gas storage. The new and updated datasets related to domestic supply are listed in **Table 18**.

Table 18. New and updated datasets for natural gas supply at high pressure from domestic production. In the column v3.10, “D” stands for “Deleted”, “N” for “New Activity”, and “U” for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas, high pressure, domestic supply with seasonal storage	CN; IT; NO; PL; RO; TR	2021-2023	natural gas, high pressure	m^3	N
natural gas, high pressure, domestic supply with seasonal storage	CA; DE; GB; MX; NL; US	2021-2023	natural gas, high pressure	m^3	U

Natural gas can be imported either over pipelines or as liquefied natural gas (LNG). The activity ‘natural gas, high pressure, import from XX’ in ecoinvent version 3.9.1/3.10 generally corresponds to the datasets ‘natural gas, production XX, at long-distance pipeline’ in (Bussa, Jungbluth, & Meili, 2023), where XX refers to the two-letter country code for the geography where the gas was produced. The geography of the import activity refers to the importing country or region. In cases where the country of origin is a net exporter of gas, the activity ‘natural gas, high pressure, import from XX’ accounts for the shares of gas imported as LNG (linked to the corresponding evaporation activity, as listed in **Table 16**) and via long-distance pipelines (linked directly to petroleum and gas production in country XX). The changes to this type of import activities for natural gas at high pressure in v3.10 is provided in **Table 19**.

Table 19. Changes to datasets for import of natural gas at high pressure from net exporters. In the column v3.10, “D” stands for “Deleted”, “N” for “New Activity”, and “U” for “Updated Activity”. The asterisk “*” indicates import activities where a proxy process was used to link supply and demand over the markets.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas, high pressure, import from AE	CN; JP; KR	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from AE	GLO	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from AU	CN; GLO; JP; KR	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from AZ	IT; RER	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from AZ	GLO; TR	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from BO	BR	2018-2021	natural gas, high pressure	m3	N
natural gas, high pressure, import from BO	GLO	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from BR	GLO	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from CA	GLO	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from CA	US	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from CN	GLO	2000-2022	natural gas, high pressure	m3	D

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas, high pressure, import from CO	GLO	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from DZ	BE; CN; NL; RER	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from DZ	GLO	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from EC	GLO	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from EG	BE; CN; ES; GLO; IT; JP; KR; RER; TR	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from ID	CN; JP; KR	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from ID	GLO; MX	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from IQ	GLO	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from IR	IQ*	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from IR	GLO; TR	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from KW	GLO	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from KZ	CN	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from KZ	GLO	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from LY	GLO; RoE	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from LY	IT	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from MX	GLO	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from MX	US	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from MY	CN; JP; KR	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from MY	GLO	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from NG	MX; US	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from NG	CN; JP; KR; NL	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from NG	ES; FR; GB; GLO; IT; RER; TR	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from NO	GLO; TR	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from NO	BE; DE; ES; FR; GB; IT; NL; RER	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from OM	CN; GLO; JP; KR	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from PE	CA; CN; ES; GB; JP; KR; NL	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from QA	AE*; CN; JP; KR; NL	2021-2023	natural gas, high pressure	m3	N

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas, high pressure, import from QA	BE; ES; FR; GB; GLO; IT; RER; TR	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from RU	CN; JP; KR	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from RU	BE; DE; ES; FR; GB; GLO; IT; NL; RER; TR	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from SA	GLO	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from TM	CN; GLO	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from TT	CA; CN; ES; GB; GLO; KR; MX; NL; RER; TR; US	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from US	CN; JP; KR; NL; RER	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from US	BE; CA; ES; FR; GB; GLO; IT; MX; TR	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from UZ	CN; GLO	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from VE	GLO	2000-2022	natural gas, high pressure	m3	D

In contrast to the import from net exporters of gas in **Table 19**, the supply from the countries listed in **Table 20** relies to varying degree on imports (depending on the extent of indigenous production in relation to own consumption). In this case, it was decided for the update in version 3.10 to model exports from these transit countries consistently over their consumption mixes. The import activities in **Table 20** only serve to connect the two market activities for natural gas at high pressure (i.e., the border-crossing), without considering any further flows (e.g., energy requirements, infrastructure inputs, or losses). Market activities for natural gas at high pressure (**Table 21**) must therefore be modelled with relative shares of supply based on own production and gross imports, while annual production volumes should refer to inland consumption, to avoid double-counting.

Table 20. New and updated datasets for import of natural gas at high pressure from net importers. In the column v3.10, “D” stands for “Deleted”, “N” for “New Activity”, and “U” for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas, high pressure, import from BE	DE; FR; GB; NL; RER	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from BE	SE	2000-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from CZ	PL		natural gas, high pressure	m3	N
natural gas, high pressure, import from DE	CH; DK; PL; RER	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from ES	FR	2021-2023	natural gas, high pressure	m3	N

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
natural gas, high pressure, import from FI	SE	2000-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from FR	BE; ES; NL	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from FR	CH	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from GB	GLO	2000-2022	natural gas, high pressure	m3	D
natural gas, high pressure, import from GB	NL; RER	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from HU	RO	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from IT	CH; RER	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from NL	CH; DE; FR; GB; IT; RER	2021-2023	natural gas, high pressure	m3	U
natural gas, high pressure, import from PL	RER	2021-2023	natural gas, high pressure	m3	N
natural gas, high pressure, import from TR	GR	2000-2023	natural gas, high pressure	m3	U

The supply of natural gas in 2021 was modelled for selected countries within the EU, Norway, and Turkey based on statistics on imports by trade partner and own production from EuroStat (EuroStat, 2023a) (EuroStat, 2023b). The geographical coverage of country-specific gas supply at high pressure within EU-27 remained unchanged over the previous version of the ecoinvent database. The supply situation in the United Kingdom was derived from the '*Digest of UK Energy Statistics' (DUKES)* (BEIS, 2022), for Switzerland from (VSG, 2022) in (Bussa, Jungbluth, & Meili, 2023), and on BP's *'Statistical Review of World Energy'* from June 2022' (BP, 2022) for countries modelled in the rest of the world. Imports to Rest-of-Europe (RoE) and the Rest-of-the-World (RoW) geographies were calculated by subtracting the sum of country-specific supply modelled separately from the total import of the respective regions. New market activities for local distribution (at low pressure) were added for China (CN), Japan (JP), and South Korea (KR). (**Table 21**)

Table 21. New and updated datasets for regional and local distribution of natural gas. In the column v3.10, "D" stands for "Deleted", "N" for "New Activity", and "U" for "Updated Activity".

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
market for natural gas, high pressure	AR; AU; BO; EG; IN; KR; OM; PE; TH; TM; TT; TW; UZ	2019-2023	natural gas, high pressure	m3	N
market for natural gas, high pressure	AE; AZ; BE; BR; CA; CH; CO; CZ; DE; DK; DZ; EC; ES; FR; GB; GLO; GR; HU; IE; ID; IT; IQ; IR; JP; KW; KZ; LY; MX; MY; NG;	2019-2023	natural gas, high pressure	m3	U

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
	NO; PL; QA; RER; RU; SA; SE; SK; TR; US; VE				
natural gas pressure reduction, from high to low pressure	CN; JP; KR; RER	2010-2010	natural gas, low pressure	m3	N
natural gas pressure reduction, from high to low pressure	CA	2010-2010	natural gas, low pressure	m3	U
market for natural gas, low pressure	CN; JP; KR	2021-2023	natural gas, low pressure	m3	N
market for natural gas, low pressure	BE; CA; CH; DE; ES; FR; GB; GLO; IT; MX; NL; TR; RER; US	2021-2023	natural gas, low pressure	m3	U

Full geographical coverage without overlaps was achieved for Europe and globally by preparing market shares for the Rest of Europe (RoE) and Rest-of-the-World (RoW) geography, respectively. The situation in Europe was modelled based on information from EuroStat, based on (EuroStat, 2023a) and (EuroStat, 2023b), by subtracting the sum of country-specific supply modelled in v3.10 from the total import to EU-27 countries in 2021. Analogously to petroleum supply, the RoW mix was derived as the difference between global supply in (BP, 2022) and the sum of the region-specific markets.

3.1.4.5 Supply of petroleum and natural gas in the consequential system model

As for 3.9.1, the LCIA results for the update of petroleum and natural gas supply chains in 3.10 in the system model ‘Substitution, consequential, long-term’ are generally closely aligned with the results in the attributional ‘Allocation, cut-off by classification’ for most impact categories. Further work is needed to establish and implement a consequential model for the sector in the database. The direct linking of these supply chains is hence essentially identical across the different system models in version 3.9. Differences in results are hence caused further upstream, in the product system of process inputs, mainly due to differences in electricity supply, or from recycling or waste treatment services.

3.1.5 Other updates

As part of the ‘Cornerstone’ project for version 3.8, which improved the representation of fuel supply chains in Brazil, direct links were set between domestic activities for petroleum production and refinery operation. The activity links became redundant through the introduction of a dedicated market for petroleum in Brazil with version 3.10, and they were hence removed from the petroleum refinery operations datasets (**Table 22**).

Table 22. Updated datasets for petroleum refinery operation in Brazil (BR). In the column v3.10, "U" stands for "Updated Activity".

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
C3 hydrocarbon production, mixture, petroleum refinery operation	BR	2014-2017	C3 hydrocarbon mixture	kg	U
base oil production, petroleum refinery operation	BR	2014-2017	base oil	kg	U
diesel production, low-sulfur, petroleum refinery operation	BR	2014-2017	diesel, low-sulfur	kg	U
diesel production, petroleum refinery operation	BR	2014-2017	diesel	kg	U
heavy fuel oil production, petroleum refinery operation	BR	2014-2017	heavy fuel oil	kg	U
hydrogen production, gaseous, petroleum refinery operation	BR	2014-2017	hydrogen, gaseous, low pressure	kg	U
kerosene production, petroleum refinery operation	BR	2014-2017	kerosene	kg	U
light fuel oil production, petroleum refinery operation	BR	2014-2017	light fuel oil	kg	U
liquefied petroleum gas production, petroleum refinery operation	BR	2014-2017	liquefied petroleum gas	kg	U
naphtha production, petroleum refinery operation	BR	2014-2017	naphtha	kg	U
petrol production, unleaded, petroleum refinery operation	BR	2014-2017	petrol, unleaded	kg	U
petroleum slack wax production, petroleum refinery operation	BR	2014-2017	petroleum slack wax	kg	U
pitch production, petroleum refinery operation	BR	2014-2017	pitch	kg	U
refinery gas production, petroleum refinery operation	BR	2014-2017	refinery gas	kg	U
reformate production, petroleum refinery operation	BR	2014-2017	reformate	kg	U
sulfur production, petroleum refinery operation	BR	2014-2017	sulfur	kg	U
white spirit production, petroleum refinery operation	BR	2014-2017	white spirit	kg	U

The import and regional distribution (i.e., markets) for four refined petroleum products in Switzerland, listed in **Table 23**, was updated based on (Jungbluth & Meili, 2018), but using the most recent statistics available for the shares of domestic production vs. imports from the EU. It should be noted that diesel imported and consumed in Switzerland is assumed to generally have a lower sulfur content (corresponding to the product 'diesel, low-sulfur' in the database). The datasets for 'diesel' should only be considered proxy activities (without real annual production volumes), at least enabling the same share of import to be reflected in the supply of 'diesel' to older activities that are modelled with an input of this inferior diesel quality.

Table 23. **Updated datasets for import and regional distribution of refined petroleum products in Switzerland (CH).** In the column v3.10, “U” stands for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
diesel, import from Europe	CH	2000-2023	diesel	kg	U
diesel, low-sulfur, import from Europe	CH	2000-2023	diesel, low-sulfur	kg	U
light fuel oil, import from Europe	CH	2000-2023	light fuel oil	kg	U
market for diesel	CH	1989-2023	diesel	kg	U
market for diesel, low-sulfur	CH	2000-2023	diesel, low-sulfur	kg	U
market for light fuel oil	CH	1989-2023	light fuel oil	kg	U
market for petrol, low-sulfur	CH	1989-2023	petrol, low-sulfur	kg	U
petrol, low-sulfur, import from Europe	CH	2000-2023	petrol, low-sulfur	kg	U

3.2 Coke production

New Chinese [CN] by-product coke producing datasets were created based on the publication of (Liu & Yuan, 2016). The publication differentiates between “wet quenching” and “dry quenching” technology, for which two individual datasets were created. These datasets feed into a newly created Chinese coke market (**Figure 5**). The previous GLO “coke production” dataset, based on US values and emissions, was recontextualized as “coke production, US” and a new GLO dataset, based on a weighted average of the CN, German [DE] and US production, was created. The DE, US and GLO/RoW productions feed the GLO/RoW market for coke. Exchanges between the CN and GLO/RoW are considered and modelled as import datasets. Production volumes and thus market shares for all producing activities as well as prices for the main coke product, but also for the by-products of coal tar, coal gas, benzene, were updated.

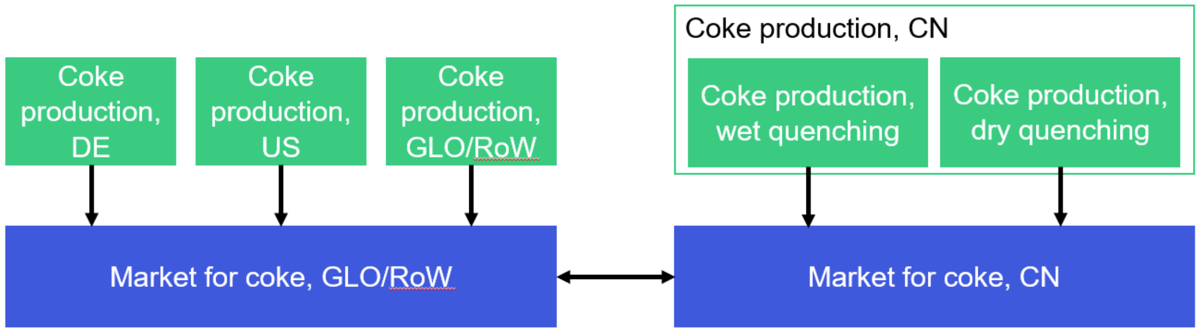

Figure 5. Transforming and market activities for coke in v3.10.

The following table (**Table 24**) lists all newly created and updated datasets around by-product coke production in the ecoinvent database.

Table 24. New and updated datasets for coke production. In the column v3.10, "N" stands for "New Activity" and "U" stands for "Updated Activity.

Activity Name	**Geography**	**Time Period**	**Product Name**	**Unit**	**v3.10**
coke production	US	1990-2000	coke	MJ	N
coke production	GLO	1980-2024	coke	MJ	U
coke production, dry quenching	CN	2013-2024	coke	MJ	N
coke production, wet quenching	CN	2013-2024	coke	MJ	N
coke, import from CN	GLO	2015-2020	coke	MJ	N
market for coke	CN	2013-2024	coke	MJ	N
market for coke	GLO	2011-2011	coke	MJ	U

4 Chemicals

4.1 Overview of the update

The chemicals sector is updated to improve the data representation for essential chemical precursors and their derivatives, such as short-chain alkenes (ethylene, propylene, butene, and butadiene), monocyclic aromatics (benzene, toluene, and xylenes [p-, o-, mixed]), ethylene oxide, and ethylene glycol. Industry data for European conditions was provided by Plastics Europe. Additional key updates comprise of technological and geographical coverage expansion for ethylene, propylene, hydrogen, and methanol. Specifically, ecoinvent v3.10 introduces data for China, United States, and Europe. Moreover, ecoinvent v3.10 introduces updated industry data covering the supply and demand of chlorine and sodium hydroxide, provided by Euro Chlor, diisocyanates (methylene diphenyl diisocyanate and toluene diisocyanate) and polyether polyols (short- and long-chain), provided by ISOPA. This version also introduces data for industrial cooling supply for process streams at temperatures well below ambient, i.e., –15, –25, –45, –55, –100, and –160 °C. Finally, the chemicals sector in ecoinvent v3.10 takes a step to a comprehensive content update. This content update focuses on nomenclature, documentation, technological relevance, inventory completeness, and harmonisation following the standard ecoinvent approach.

4.2 Updates of the hydrogen value chain

This update is part of a continuous effort to enhance the technological and geographical coverage for dedicated production, supply, specifications, and utilisation of hydrogen in different industries. The supply of by-product hydrogen is tackled also in the chlorine production and steam cracking operations updates, amongst other by-product suppliers. A schematic representation of this update is illustrated in **Figure 6**.

To provide the hydrogen supply specifications, the exchanges “hydrogen, gaseous” and “hydrogen, liquid” are revised as follows. Namely, the former is split into two exchanges with distinct pressure levels, while the latter is excluded. A “hydrogen, gaseous, low pressure” exchange covers the supply of hydrogen at ca. 25 bar, that may be considered available on-site or in close vicinity from the production facility, with no transport of the substance. The “hydrogen, gaseous, medium pressure, merchant” represents hydrogen that is ready for transportation at 200 bar, which is also in accordance with the IEA Hydrogen Task 36 (Iribarren D, 2018). The latter exchange substituted the “hydrogen, liquid” one, while in future releases the liquefaction step will be introduced. For more information on the renaming, please consult **Table 1** and **Table 2**.

In version 3.9.1, the activity “hydrogen production, steam reforming” supplied hydrogen at 200 bar. In the new version, this dataset is disaggregated into distinct production and compression data. The updated activity supplies hydrogen at 25 bar, while the “hydrogen compression, from low to medium pressure” dataset increases the pressure to 200 bar. The impact assessment scores remained relatively unchanged since the disaggregation is based on the original dataset and source. Finally, the dataset “hydrogen production, coal gasification” is created, with an expected hydrogen output pressure greater than 20 bar and up to 55 bar. The calculated global warming potential for both the coal- and natural gas-based production are in alignment with literature (Parkinson, 2019), where the former, depending on the production location, is 1.8–2.2 times higher than the latter.

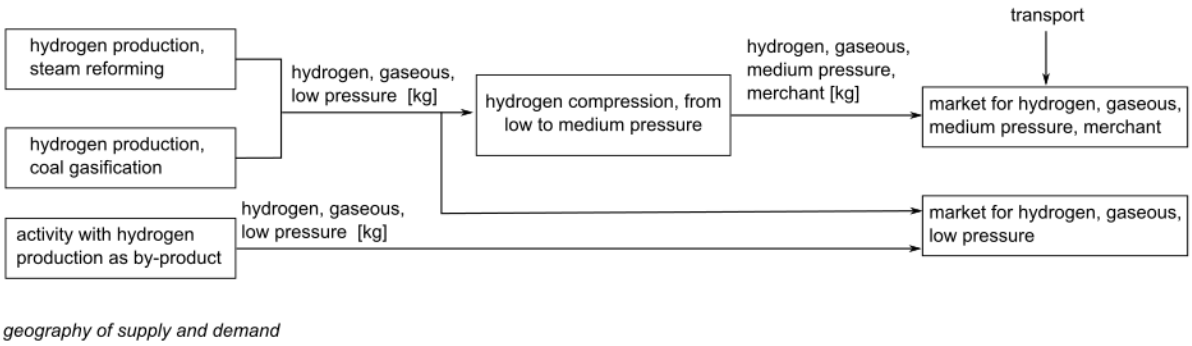

Figure 6. Schematic illustration of the supply chain modelling for hydrogen in ecoinvent version 3.10.

Regional production and market activities are introduced in China, the United States, Europe, and the Rest-of-World (RoW), in accordance with reported data for 2020. In version 3.9.1, the market for hydrogen is based on by-product sources, and thus, the key outcome of this update is the improved market configuration. Besides, the hydrogen production from coal and natural gas contributed to approximately 93% of the Global output in 2020, with half being produced in China, United States, and Europe. Relative score changes are illustrated in **Table 25**, where the anticipated score increase can be observed in most indicators and for all geographies. The US and CN markets are compared to the RoW market from v3.9.1. The share of coal-based hydrogen production in China lead to the observed higher relative change compared to Europe. The main score contributors of coal-based hydrogen are the direct carbon dioxide release and the coal and electricity consumption.

Table 25. Relative changes in scores (EF 3.1) between versions 3.9. and 3.10 (system model: allocation, cut-off) for the “market for hydrogen, gaseous, low pressure” (old: hydrogen, gaseous).

LCIA impact category – EF 3.1	RER	US	CN	RoW
acidification-accumulated exceedance (AE)	-50%	-61%	116%	-26%
climate change-global warming potential (GWP100)	307%	330%	704%	297%
ecotoxicity: freshwater; comparative toxic unit for ecosystems (CTUe)	-83%	-82%	-34%	-79%
energy resources: non-renewable; abiotic depletion potential (ADP): fossil fuels	17%	19%	22%	14%
eutrophication: freshwater; fraction of nutrients reaching freshwater end compartment (P)	236%	508%	2761%	713%
eutrophication: marine; fraction of nutrients reaching marine end compartment (N)	-17%	-35%	176%	-1%
eutrophication: terrestrial; accumulated exceedance (AE)	-6%	-25%	207%	11%
human toxicity: carcinogenic; comparative toxic unit for human (CTUh)	1939%	1727%	1320%	1585%

human toxicity: non-carcinogenic; comparative toxic unit for human (CTUh)	16%	15%	118%	38%
ionising radiation: human health; human exposure efficiency relative to u235	184%	157%	395%	166%
land use; soil quality index	-44%	-25%	305%	-23%
material resources: metals/minerals; abiotic depletion potential (ADP): elements (ultimate reserves)	1554%	1200%	1842%	1712%
ozone depletion; ozone depletion potential (ODP)	167%	-40%	-65%	52%
particulate matter formation; impact on human health	-60%	-65%	767%	-43%
photochemical oxidant formation: human health; tropospheric ozone concentration increase	-15%	-7%	14%	-4%
water use-user deprivation potential (deprivation-weighted water consumption)	833%	858%	741%	795%

The new, updated, and deleted datasets within this project are listed in **Table 26**.

Table 26. List of affected 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 “v3.10”, “N” stands for “New Activity”, “U” stands for "Updated Activity” and “D” stands for "Deleted Activity”.

Activity Name in v3.10	Geography	Time Period	Product Name	Unit	v3.10
hydrogen production, coal gasification	CN; GLO; US	2022-2026	hydrogen, gaseous, low pressure	kg	N
hydrogen production, steam methane reforming	CN; US	2020-2025	hydrogen, gaseous, low pressure	kg	N
hydrogen production, steam methane reforming	GLO; RER	2020-2025	hydrogen, gaseous, low pressure	kg	U
hydrogen cracking, APME	GLO; RER	1999-2001	hydrogen, liquid	kg	D
hydrogen compression, from low to medium pressure	GLO; RER; US	2023-2023	hydrogen, gaseous, medium pressure, merchant	kg	N
market for hydrogen, gaseous, medium pressure, merchant	US	2020-2023	hydrogen, gaseous, medium pressure, merchant	kg	U
market for hydrogen, gaseous, medium pressure, merchant	GLO; RER	2020-2023	hydrogen, gaseous, medium pressure, merchant	kg	U

4.3 Update of the methanol value chain

Methanol is a key chemical building block for a wide range of bulk, specialty, and fine chemicals, including monomers used in plastics production. Methanol is produced from synthesis gas that is, in turn, generated from different fossil feedstocks. Namely, natural gas and coal-based facilities cover approximately 55-65% and 30-35% of global production, respectively (NETL, 2023). Hence, this update aims to enhance the technological and geographical coverage for methanol as illustrated in **Figure 7**.

In version 3.9.1, the “methanol production” dataset represented the averaged natural gas-based reforming (Althaus, 2007). This dataset is updated based on a process equipped with a single train of combined reformers. The most important units covered are the conventional steam methane reformer, followed by an oxygen blown autothermal reformer, and the methanol synthesis and purification stage, yielding AA grade methanol. This activity is renamed to “methanol production, natural gas reforming”. To reflect the methanol production worldwide better, the dataset “methanol production, coal gasification” is created. The calculated global warming potential for both the coal- and natural gas-based production are in alignment with reported values (Methanol Institute, 2023). Regional production and market activities are introduced in China, the United States, Europe, and the Rest-of-World, in accordance with data for 2021. Coal-based production is only covered for China and Rest-of-World since the former region is the primary supplier of coal-based methanol. Relative score changes for the “market for methanol” are illustrated in **Table 27**, with minor changes taking place for most indicators and all geographies except China. The markets in the US and CN are compared to the RoW market in v3.9.1. Similar to hydrogen, the coal-based activities in China have higher scores relative to the RoW market in v3.9.1.

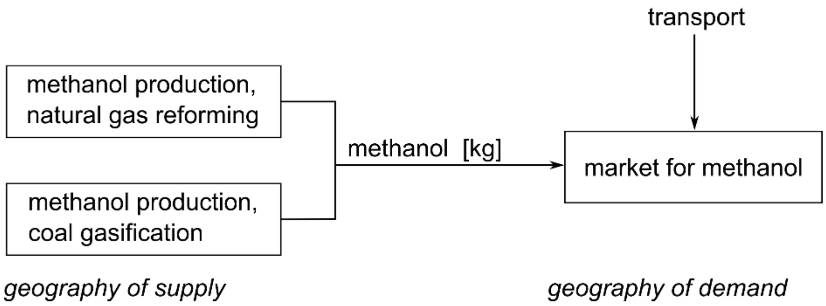

Figure 7. Schematic illustration of the supply chain modelling for methanol in ecoinvent version 3.10.

Table 27. Relative changes in scores (EF 3.1) between versions 3.9.1 and 3.10 (system model: allocation, cut-off) for the “market for methanol” in the covered geographical regions.

LCIA impact category – EF 3.1	RER	US	CN	RoW
acidification-accumulated exceedance (AE)	-25%	-38%	389%	11%
climate change-global warming potential (GWP100)	25%	14%	373%	25%

ecotoxicity: freshwater; comparative toxic unit for ecosystems (CTUe)	-8%	6%	3953%	66%
energy resources: non-renewable; abiotic depletion potential (ADP): fossil fuels	18%	14%	61%	16%
eutrophication: freshwater; fraction of nutrients reaching freshwater end compartment (P)	-24%	-22%	1066%	37%
eutrophication: marine; fraction of nutrients reaching marine end compartment (N)	-19%	-35%	267%	-6%
eutrophication: terrestrial; accumulated exceedance (AE)	-23%	-36%	243%	-11%
human toxicity: carcinogenic; comparative toxic unit for human (CTUh)	1273%	1199%	1551%	971%
human toxicity: non-carcinogenic; comparative toxic unit for human (CTUh)	-13%	-11%	270%	-6%
ionising radiation: human health; human exposure efficiency relative to u235	95%	83%	754%	-13%
land use; soil quality index	2%	18%	696%	0%
material resources: metals/minerals; abiotic depletion potential (ADP): elements (ultimate reserves)	-7%	-14%	261%	-8%
ozone depletion; ozone depletion potential (ODP)	112%	-54%	-49%	14%
particulate matter formation; impact on human health	-9%	-18%	1978%	-3%
photochemical oxidant formation: human health; tropospheric ozone concentration increase	7%	18%	105%	22%
water use-user deprivation potential (deprivation-weighted water consumption)	-54%	-57%	496%	-52%

To expand further the technological coverage in China, datasets for the production of light olefins, such as ethylene and propylene, from methanol are introduced. Methanol-based olefins production was first introduced by Mobil Corporation in 1977 (Chang, 1977), commercialized in 2010 (Peng Tian, 2015), and could secure and broaden the resources used to produce polymers (Bertau, 2014). Such facilities operate in China and use coal-based methanol at high shares (Chen, 2017). In coal-to-XX conversion facilities (with XX being either olefins or propylene), the production starts with the coal mining operations, while methanol-to-XX facilities are supplied by the regional market.

In ecoinvent version 3.10, two datasets for the methanol-to-olefins conversion are created since the output depends on the operating conditions and the catalyst used. To cover the on-purpose methanol-to-propylene production, with gasoline as byproduct, an additional dataset is included. Furthermore, to represent coal-to-XX facilities, activity links are used to by-pass, partly, the market activities. A schematic representation of this update is illustrated in **Figure 8**. The data creation, supply, and share of each technology are based on process data and estimates from literature data for the years 2014-2021. Since China represents the primary operator of such technologies, this data is only covered in this region and supply the Rest-of-World markets. The efforts for improving further the regional and technological coverage within China will continue in future releases.

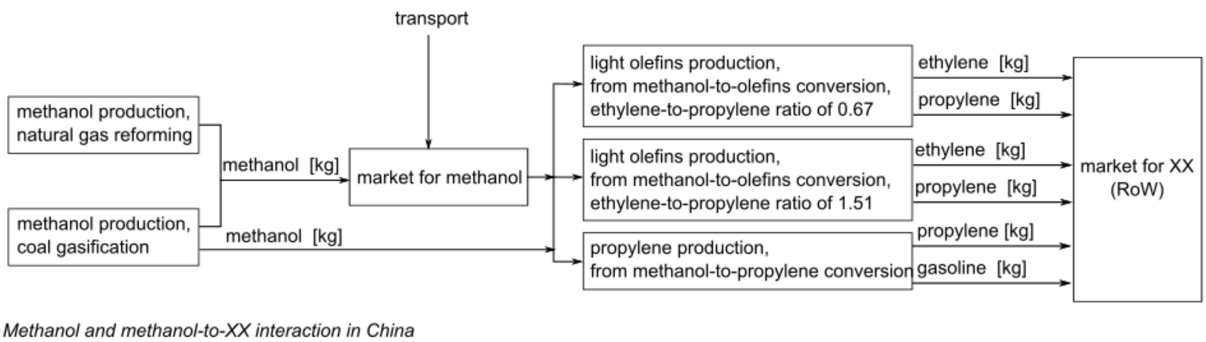

Figure 8. Schematic illustration of the supply chain modelling for methanol-to-olefins or propylene in ecoinvent version 3.10.

All updates of datasets along the methanol supply chain are summarised in **Table 28**.

Table 28. New and updated 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 "v3.10", "N" stands for "New Activity", "U" stands for "Updated Activity" and "D" stands for "Deleted Activity".

Activity Name in v3.10	Geography	Time Period	Product Name	Unit	v3.10
methanol production, natural gas reforming	CN; RER; US	2017-2025	methanol	kg	N
methanol production, natural gas reforming	GLO	2017-2025	methanol	kg	U
methanol production, coal gasification	CN; GLO	2020-2025	methanol	kg	N
light olefins production, from methanol-to-olefins conversion, ethylene-to-propylene ratio of 0.67	CN	2021-2021	ethylene; propylene	kg; kg	N
light olefins production, from methanol-to-olefins conversion, ethylene-to-propylene ratio of 1.51	CN	2022-2026	ethylene; propylene	kg; kg	N
propylene production, from methanol-to-propylene conversion	CN	2020-2020	propylene	kg	N
market for methanol	CN; RER; US	2011-2011	methanol	kg	N

4.4 Update of key polymer precursors value chain

Light olefins and monocyclic aromatics are the most essential raw materials used in the production of a wide range of chemicals and plastics, which, in turn, are consumed in most manufactured goods (e.g., electronics, appliances, and automotive industry). This update, performed in collaboration with PlasticsEurope, aims on improving the database content related to

- light olefins, such as ethylene, propylene, butene, and butadiene,

- monocyclic aromatics, such as benzene, toluene, and xylenes (p-, o-, mixed), i.e., BTX, and
- ethylene derivatives, i.e., ethylene oxide and ethylene glycols.

The key outcome of this project is the replacement of outdated aggregated datasets for olefins and aromatics mentioned above, along with the hydrogen from cracking, with disaggregated ones. Hence, the oil and gas update of ecoinvent version 3.9 (Moreno Ruiz, et al., 2022) is now reflected in the value chain of these key precursors.

In this update, the datasets “unsaturated hydrocarbons production, steam cracking operation, average”, “BTX production, from reformate, average”, “BTX production, from pyrolysis gas, average”, “ethylene oxide production, ethylene oxidation”, “ethylene glycols production, thermal hydrolysis of ethylene oxide”, “butadiene purification, extractive distillation of crude butadiene”, and “propylene production, from propane dehydrogenation” are introduced. The steam cracking activity represents the average European operations, where heavier feedstocks are predominantly used (see **Table 29**). The pyrolysis gas (containing BTX) from the steam cracker and reformate from the petroleum refinery are fed into the respective average datasets. For the latter feedstocks, an activity link is introduced due to their respective proximity. Finally, another activity link is used for hydrogen used in the hydrotreatment of the aromatic feedstock and sourced from the respective steam cracking or refinery operations. A schematic representation of the configuration mentioned above is illustrated in **Figure 9**.

Regarding the RER geography, the data used, excluding propane dehydrogenation, are representative for minimum 80% of the European production (PlasticsEurope, 2021a; PlasticsEurope, 2021b). Namely, the primary steam cracking data originate from the years 2018-2019. Moreover, the data for the BTX extraction are based on the year 2012 along with literature data from the years 1995-2017. Finally, the production of ethylene oxide, ethylene glycol, and propylene via propane dehydrogenation are based on literature. Focusing on the “propylene production, from propane dehydrogenation”, this activity is covered for the United States, China, and Rest-of-World, in accordance with data for 2021. Finally, for the Rest-of-World geography, the European data with the feedstock mix are recontextualised and included, which may be considered as a sensible first approximation for replacing the aggregated datasets. ecoinvent aims at improving further the representation of other world regions in future releases.

Table 29. Share of feedstock in the European Union crackers for 2018 (PlasticsEurope, 2021a).

Feedstock	Share (%)
Naphtha	64.0%
Butane	16.2%
Propane	7.6%
Ethane	4.5%
Gas oil	4.0%

Condensates (NGL)	2.2%
Refinery gas	1.5%

The steam cracking and BTX production activities, illustrated in **Figure 9**, represent complex processes with multiple valuable outputs. Several sensitivity assessments were conducted, considering the reference product subdivision, i.e., by mass, lower heating value (LHV), and carbon content. The three subdivision approaches lead to similar outcomes. Hence, the following allocation of inputs and outputs between reference and by-products, based on economic rational, was barely impacted by the previous subdivision. After careful considerations, it was decided to tackle the multi-functionality in accordance with Plastics Europe (2017) using a flow specific approach (PlasticsEurope, 2017).

In the steam cracking operations, feedstock is partitioned to all allocatable outputs by mass, whereas emissions and utilities are only assigned to intended products (ethylene, propylene, crude butadiene, pyrolysis gas –cont. BTX–, butene, and hydrogen) by mass. In the BTX production, feedstock is partitioned to all allocatable outputs by mass, whereas all the other inputs and outputs (energy and other input, emissions, and solid wastes) are assigned based on information from individual process steps only to reference products (i.e., benzene, toluene, o-xylene, p-xylene, and xylenes, mixed). The latter approach is also in accordance with the methodology followed for tackling multi-functionality for the petroleum refinery operations in ecoinvent (Fehrenbach H., 2018).

Relative score changes for the market for ethylene and propylene are illustrated in **Table 30** where a systematic increase in relative scores is observed. To name a few affected indicators for the European market, acidification score increased by 11-14%, climate change by 31-35%, and abiotic depletion potential–fossil fuels by 4-6%. Substantial score increases, e.g., >500%, may be attributed to the consideration of infrastructure for steam cracking and upstream operations, such as petroleum refinery and natural gas pipeline. Nonetheless, concrete conclusions cannot be made due to the aggregated state of the replaced datasets. Such relative score changes propagate downstream, e.g., ethylene oxide, ethylene glycol, and polyolefins production. The score changes for the European market of benzene, toluene, and xylenes (o-, p-, and mixed-) are similar to that of light olefins, as visualised in **Figure 10**, and thus, their discussion of scores in this report is omitted.

The Rest-of-World scores for ethylene and propylene are influenced at a higher extent compared to their European counterpart (**Table 30**), which is not the case for monocyclic aromatics. This effect is mainly attributed to the inclusion of alternative technologies in China. Besides, the latter region is one of the major light olefins producers worldwide and has several coal-to- and methanol-to-olefins facilities in operation (**Figure 9**). Such facilities, in turn, lead to the higher release of fossil carbon to the atmosphere.

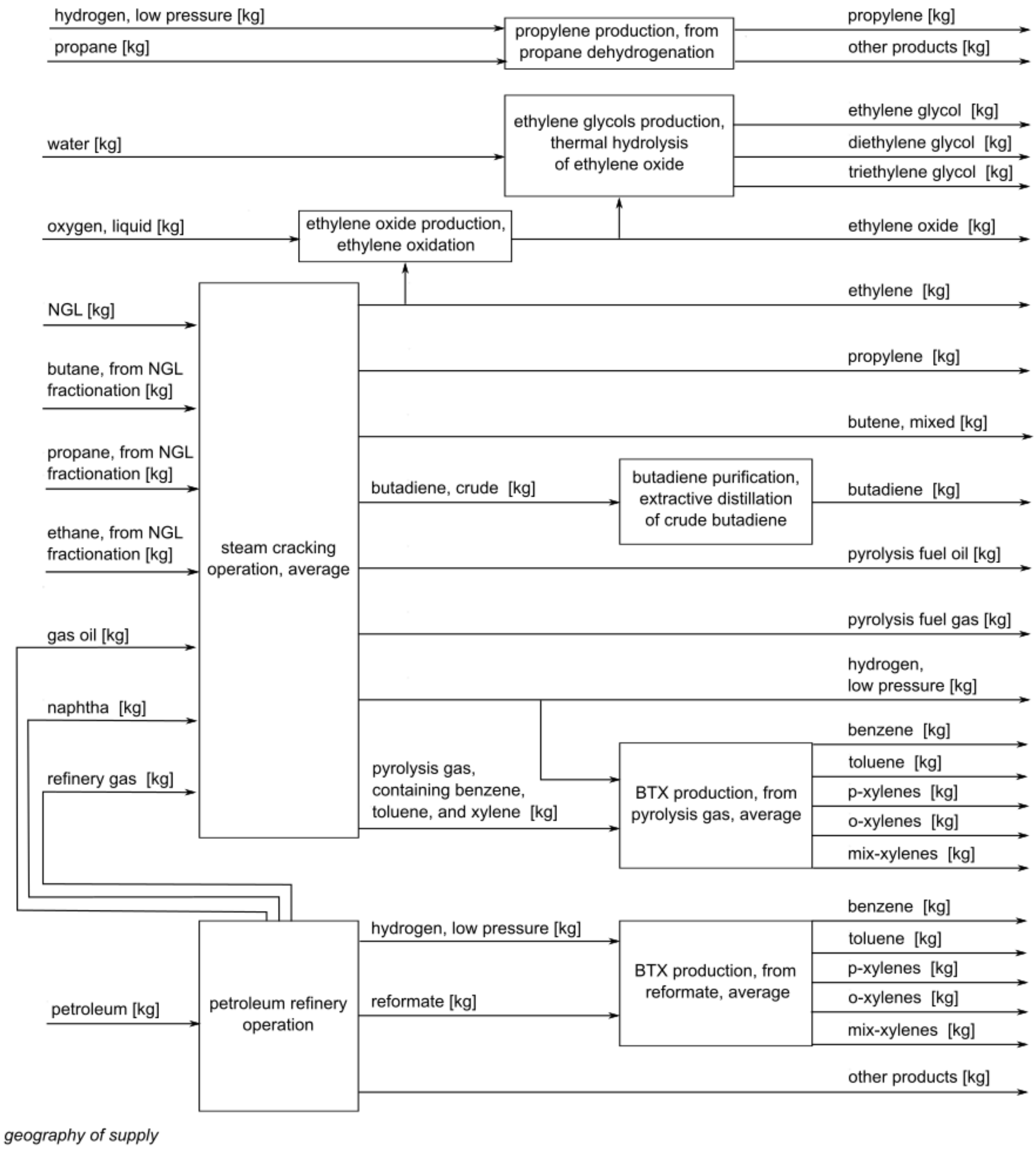

Figure 9. Schematic illustration of the key polymer precursors value chains update in ecoinvent versions 3.10.

Table 30. Comparison of relative change in scores (EF 3.1) between version 3.9.1 and 3.10 (system model: allocation, cut-off) for the market for ethylene and propylene for RER (and RoW is provided in the parenthesis).

LCIA impact category – EF 3.1	Ethylene	Propylene
acidification-accumulated exceedance (AE)	14% (82%)	11% (90%)
climate change-global warming potential (GWP100)	35% (56%)	31% (99%)
ecotoxicity: freshwater; comparative toxic unit for ecosystems (CTUe)	2572% (9353%)	2506% (14182%)
energy resources: non-renewable; abiotic depletion potential (ADP): fossil fuels	6% (9%)	4% (17%)
eutrophication: freshwater; fraction of nutrients reaching freshwater end compartment (P)	2104% (3967%)	1961% (4798%)
eutrophication: marine; fraction of nutrients reaching marine end compartment (N)	25% (85%)	31% (110%)
eutrophication: terrestrial; accumulated exceedance (AE)	20% (79%)	26% (101%)
human toxicity: carcinogenic; comparative toxic unit for human (CTUh)	11719% (12917%)	10891% (11221%)
human toxicity: non-carcinogenic; comparative toxic unit for human (CTUh)	943% (876%)	890% (1207%)
ionising radiation: human health; human exposure efficiency relative to u235	53174% (59955%)	51204% (81179%)
land use; soil quality index	36346% (45207%)	34442% (45480%)
material resources: metals/minerals; abiotic depletion potential (ADP): elements (ultimate reserves)	31522% (38511%)	41489% (43954%)
ozone depletion; ozone depletion potential (ODP)	27872% (21880%)	27291% (22470%)
particulate matter formation; impact on human health	-22% (63%)	-25% (122%)
photochemical oxidant formation: human health; tropospheric ozone concentration increase	132% (149%)	137% (153%)
water use-user deprivation potential (deprivation-weighted water consumption)	-44% (-12%)	-44% (46%)

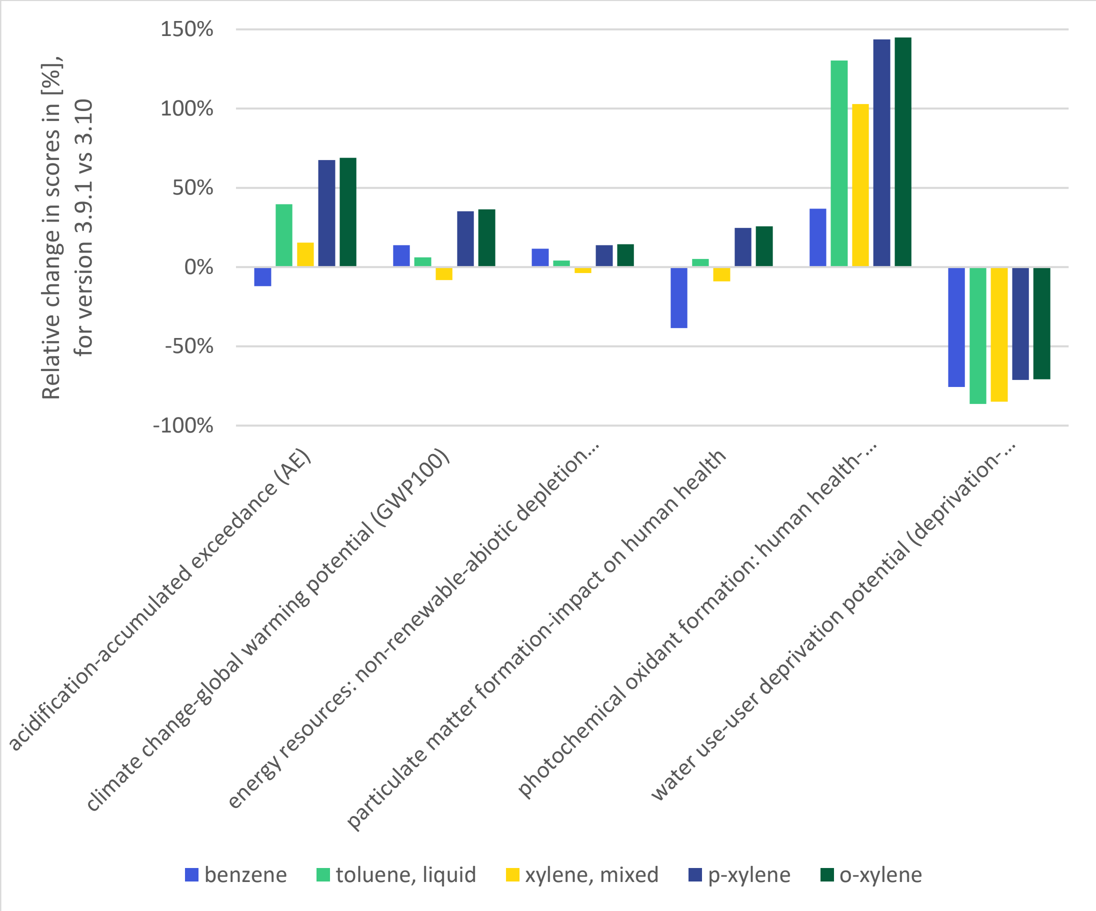

Figure 10. **Comparison of relative change in scores** (selected EF 3.1 indicators) between version 3.9.1 and 3.10 (system model: allocation, cut-off) for the market activities for benzene, toluene, mixed xylene, p-xylene and p-xylene in the geography RER.

Table 31 contains all datasets which were deleted from v3.9.1 and replaced with a new, disaggregated unit process datasets in v3.10. **Table 32** lists datasets updated within the light olefins, monocyclic aromatics and ethylene derivatives project.

Table 31. Replaced 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 v3.9.1	Product Name v3.9.1	Activity Name v3.10	Product Name v3.10	Geography	Time Period
benzene production toluene production, liquid xylene production	benzene toluene, liquid xylene	BTX production, from pyrolysis gas, average; BTX production, from reformate, average	benzene; toluene, liquid; xylene, mixed; o-xylene; p-xylene	RER; GLO	2019-2023
butadiene production	butadiene	butadiene purification, extractive distillation of crude butadiene	butadiene	GLO; RER	2019-2023

butene production, mixed	butene, mixed	unsaturated hydrocarbons production, steam cracking operation, average	butene, mixed; ethylene; propylene; pyrolysis gas, containing benzene, toluene and xylene	RER; GLO	2019-2023
ethylene production, average	ethylene				
propylene production	propylene				
ethylene production, pipeline system	ethylene, pipeline system	market for ethylene	ethylene	RER; GLO	2018-2023
market for ethylene, pipeline system	ethylene, pipeline system				
market for propylene, pipeline system	propylene, pipeline system	market for propylene	propylene	RER; GLO	2018-2023
propylene production, pipeline system	propylene, pipeline system				

Table 32. New and updated 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 “v3.10”, “N” stands for “New Activity”, “U” stands for "Updated Activity".

Activity Name in v3.10	Geography	Time Period	Product Name	Unit	v3.10
ethylene glycols production, thermal hydrolysis of ethylene oxide	GLO; RER	2019-2023	diethylene glycol; ethylene glycol; triethylene glycol	kg; kg; kg	U
ethylene oxide production, ethylene oxidation	GLO; RER	2019-2023	ethylene oxide	kg	U
propylene production, from propane dehydrogenation	CN; GLO; US	2022-2022	propylene	kg	N
market for benzene	RER	2011-2011	benzene	kg	N
market for butadiene, crude	GLO	2022-2022	butadiene, crude	kg	N
market for butene, mixed	GLO	2011-2011	butene, mixed	kg	U
market for butene, mixed	RER	2018-2018	butene, mixed	kg	U
market for diethylene glycol	RER	2018-2018	diethylene glycol	kg	N
market for ethylene glycol	RER	2018-2018	ethylene glycol	kg	N
market for hydrocarbons, aromatic, cyclic (C9+)	GLO	2022-2022	hydrocarbons, aromatic, cyclic (C9+)	kg	N
market for o-xylene	GLO; RER	2022-2022	o-xylene	kg	N
market for p-xylene	GLO; RER	2022-2022	p-xylene	kg	N
market for pyrolysis fuel gas	GLO	2022-2022	pyrolysis fuel gas	kg	N
market for pyrolysis fuel oil	GLO	2022-2022	pyrolysis fuel oil	kg	N

market for pyrolysis gas, containing benzene, toluene and xylene	GLO	2022-2022	pyrolysis gas, containing benzene, toluene and xylene	kg	N
market for raffinate	GLO	2022-2022	raffinate	kg	N
market for generic C4 hydrocarbons	GLO	2019-2023	generic C4 hydrocarbons	kg	N
butadiene to generic market for generic C4 hydrocarbons	GLO; RER	2019-2023	generic C4 hydrocarbons	kg	N
butane to generic market for generic C4 hydrocarbons	GLO	2019-2023	generic C4 hydrocarbons	kg	N
butene, mixed to generic market for generic C4 hydrocarbons	GLO; RER	2019-2023	generic C4 hydrocarbons	kg	N
market for residual hydrocarbon mix, from steam cracking operations	GLO	2019-2023	residual hydrocarbon mix, from steam cracking operations	kg	N
hydrocarbons, aromatic, cyclic (C9+) to generic market for residual hydrocarbon mix, from steam cracking operations	GLO	2019-2023	residual hydrocarbon mix, from steam cracking operations	kg	N
light fuel oil to generic market for residual hydrocarbon mix, from steam cracking operations	GLO	2019-2023	residual hydrocarbon mix, from steam cracking operations	kg	N
pyrolysis fuel gas to generic market for residual hydrocarbon mix, from steam cracking operations	GLO	2019-2023	residual hydrocarbon mix, from steam cracking operations	kg	N
pyrolysis fuel oil to generic market for residual hydrocarbon mix, from steam cracking operations	GLO	2019-2023	residual hydrocarbon mix, from steam cracking operations	kg	N
raffinate to generic market for residual hydrocarbon mix, from steam cracking operations	GLO	2019-2023	residual hydrocarbon mix, from steam cracking operations	kg	N

4.5 Update of the chlor-alkali electrolysis

This update, performed in collaboration with Euro Chlor, aims at improving the database content related to the chlor-alkali electrolysis, i.e., production of chlorine and sodium hydroxide. The key outcome of this project is the use of the most up-to-date data for the European production, while the Rest-of-World activities are adjusted accordingly. The industry data used are representative for 75% of the European (EU, UK, NO, and CH) capacity of chlor-alkali electrolysis (EuroChlor, 2022). The efforts for improving further the chlor-alkali electrolysis will continue in future releases by updating the production of salt, i.e., the main raw material.

For Europe, the dataset “chlor-alkali electrolysis, average production” is included. This dataset represents the average European chlor-alkali operations, and it contains averaged data on the membrane and the diaphragm technology. The European activities for “chlor-alkali electrolysis, mercury cell” and “chlor-alkali electrolysis, diaphragm cell” datasets are excluded. Besides, the former technology was phased out in Europe, while the latter is already included in the averaged activity. To maintain a level of technological coverage, the membrane cell data is updated and provided separately. Furthermore, to describe the electrolysis step better in the European activities, the source of electricity was also updated since this is an important factor in the process. Namely, the primary data collected by Euro Chlor allowed the modelling of a more representative European averaged electricity mix used by the producers. Finally, regarding Rest-of-World, the European membrane cell data is recontextualized, while the production volumes and market shares of all chlor-alkali activities are adjusted according to reported data for 2021-2022.

All updated datasets are summarized in **Table 33**.

Table 33. New and updated 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 "v3.10", "N" stands for "New Activity", "U" stands for "Updated Activity" and "D" stands for "Deleted Activity".

Activity Name in v3.10	Geography	Time Period	Product Name	Unit	v3.10
chlor-alkali electrolysis, average production	RER	2020-2025	chlorine, gaseous	kg	U
chlor-alkali electrolysis, diaphragm cell	RER	2000-2000	chlorine, gaseous	kg	D
chlor-alkali electrolysis, diaphragm cell	GLO	2000-2000	chlorine, gaseous	kg	U
chlor-alkali electrolysis, membrane cell	CA-QC	2000-2000	chlorine, gaseous	kg	U
chlor-alkali electrolysis, membrane cell	GLO; RER	2020-2025	chlorine, gaseous	kg	U
chlor-alkali electrolysis, mercury cell	RER	2000-2000	chlorine, gaseous	kg	D
chlor-alkali electrolysis, mercury cell	GLO	2000-2000	chlorine, gaseous	kg	U
market for bleach	GLO; RER	2023-2023	bleach	kg	N
market for neutralising agent, sodium hydroxide-equivalent	RER	2012-2012	neutralising agent, sodium hydroxide-equivalent	kg	N
market for sodium hydroxide, without water, in 50% solution state	RER	2018-2018	sodium hydroxide, without water, in 50% solution state	kg	N
market for sodium hypochlorite, without water, in 15% solution state	GLO	2011-2011	sodium hypochlorite, without water, in 15% solution state	kg	U
market for sodium hypochlorite, without water, in 15% solution state	RER	2018-2018	sodium hypochlorite, without water, in 15% solution state	kg	U
soda ash, light, crystalline, heptahydrate, to generic market for neutralising agent	RER	1999-1999	neutralising agent, sodium hydroxide-equivalent	kg	N
sodium bicarbonate, to generic market for neutralising agent	RER	1999-1999	neutralising agent, sodium hydroxide-equivalent	kg	N
sodium hydroxide to generic market for neutralising agent	RER	2000-2000	neutralising agent, sodium hydroxide-equivalent	kg	N

sodium hydroxide to generic market for neutralising agent	GLO	2000-2000	neutralising agent, sodium hydroxide-equivalent	kg	U
sodium hypochlorite production, product in 15% solution state	CA-QC; GLO; RER	1997-2000	sodium hypochlorite, without water, in 15% solution state	kg	D
sodium hypochlorite to generic market for bleach	GLO; RER	2023-2023	bleach	kg	N
sodium perborate, tetrahydrate, powder to generic market for bleach	GLO; RER	2023-2023	bleach	kg	N
sodium percarbonate, powder to generic market for bleach	GLO; RER	2023-2023	bleach	kg	N

4.6 Update of the polyols and diisocyanates production

This update, performed in collaboration with ISOPA (European trade association for producers of diisocyanates and polyols), aims on improving the database content related to the main building blocks of polyurethanes, which are methylene diphenyl diisocyanate (MDI), toluene diisocyanate (TDI), and polyols (long- and short-chain). The key outcome of this project is the use of the most up-to-date European industry data, and the replacement of the aggregated dataset for polyol production. The average industry data used are representative for 80% and 100% of the European production volume for polyols and TDI/MDI, respectively (ISOPA, 2021a; ISOPA, 2021b), while the same data are recontextualized for the Rest-of-World geography. The environmental scores of polyols and diisocyanates production in Europe deviate from the values reported in the ISOPA Eco-Profiles as different background data (and hydrochloric acid allocation for MDI and TDI) is used. Such deviations amount to 28% and 15–21% higher climate change score for the polyols and diisocyanates, respectively, and prior allocation is applied.

The latter environmental scores— and their deviation from the ISOPA Eco-Profiles— were approved by ISOPA as valid and representative. In version 3.10, the aggregated datasets from the ISOPA Eco-Profiles are also included. Regarding methodology, the results reported in the ISOPA Eco-Profiles were calculated using a combined elemental and mass allocation for the by-product hydrochloric acid (HCl) of the MDI and TDI production.

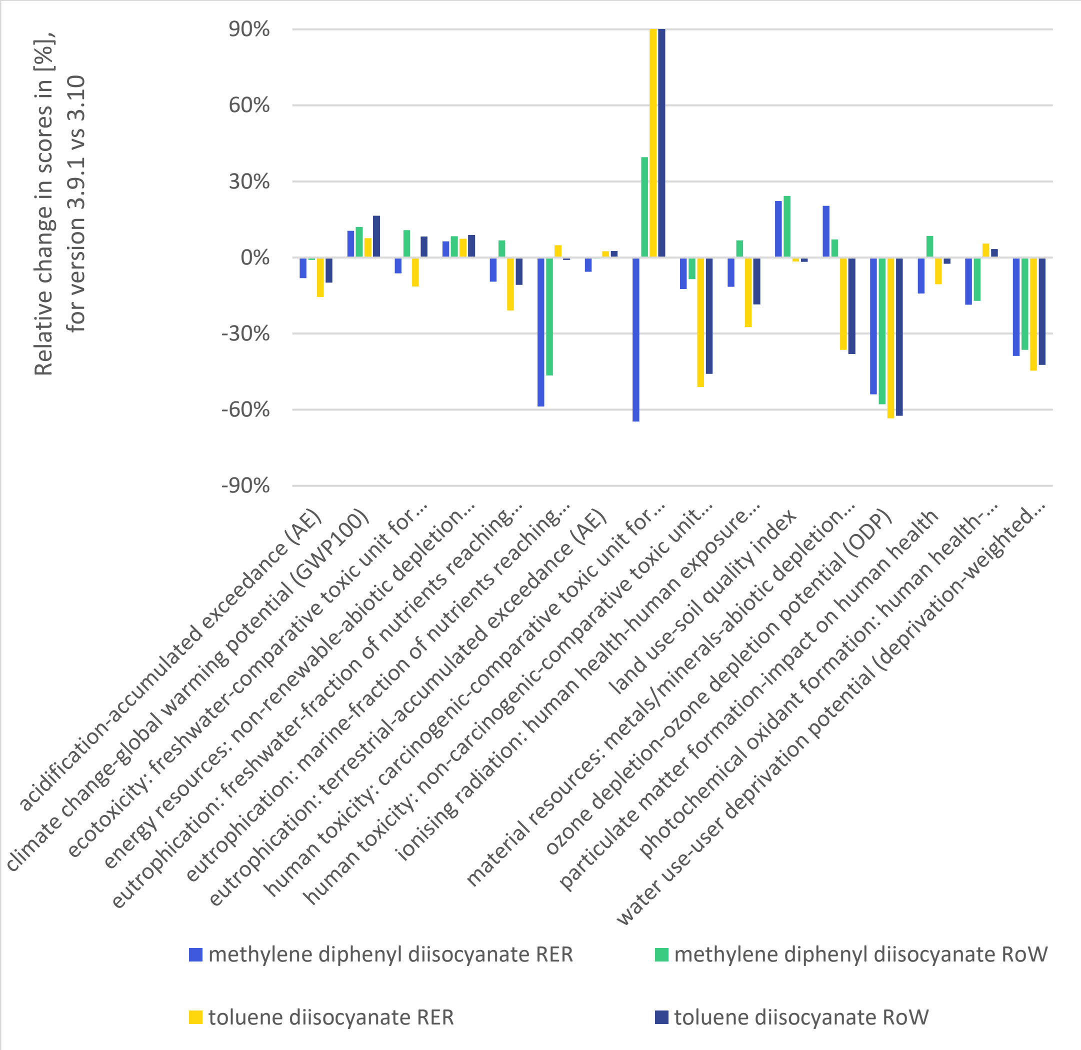

Figure 11. **Comparison of relative change in scores** (EF 3.1) between version 3.9.1 and 3.10 (system model: allocation, cut-off) for the market activities for methylene diphenyl diisocyanate and toluene diisocyanate.

Comparison of relative scores for TDI and MDI are provided in **Figure 11**, while **Table 34** lists changes for the polyether polyols. Focusing on diisocyanates in the European geography, a slight rise in scores is observed for a few indicators. The latter score changes are also influenced by the olefins, aromatics, and chlorine updates. Moreover, the score changes for polyols in same geography are affected at higher extend compared to the diisocyanates since the precursors for polyols are more affected by the olefins and monocyclic aromatics updates. Since the changes emerge due to the latter key precursors, the discussion of relative changes is herein omitted. Nonetheless, **Figure 12** is provided to illustrate the effect of all updates to the market for polyurethanes. Even though the scores for polyurethanes increased, the effect of the increasing scores due to the version 3.10 updates is damping slightly for substances downstream.

Table 34. Comparison of relative change in scores (EF 3.1) between version 3.9.1 and 3.10 (system model: allocation, cut-off) for the market for long chain and short chain polyether polyol for RER (and RoW is provided in the parenthesis).

LCIA impact category – EF 3.1	long chain polyol	short chain polyol
acidification-accumulated exceedance (AE)	-11% (53%)	0% (53%)
climate change-global warming potential (GWP100)	1% (56%)	-4% (42%)
ecotoxicity: freshwater; comparative toxic unit for ecosystems (CTUe)	-5% (3%)	-3% (6%)
energy resources: non-renewable; abiotic depletion potential (ADP): fossil fuels	3% (18%)	-10% (2%)
eutrophication: freshwater; fraction of nutrients reaching freshwater end compartment (P)	194% (224%)	178% (201%)
eutrophication: marine; fraction of nutrients reaching marine end compartment (N)	-18% (29%)	12% (49%)
eutrophication: terrestrial; accumulated exceedance (AE)	-11% (53%)	18% (68%)
human toxicity: carcinogenic; comparative toxic unit for human (CTUh)	3198% (2786%)	3354% (2953%)
human toxicity: non-carcinogenic; comparative toxic unit for human (CTUh)	60% (95%)	117% (143%)
ionising radiation: human health; human exposure efficiency relative to u235	17318% (9823%)	15053% (8858%)
land use; soil quality index	3196% (1711%)	6809% (3390%)
material resources: metals/minerals; abiotic depletion potential (ADP): elements (ultimate reserves)	136% (124%)	122% (112%)
ozone depletion; ozone depletion potential (ODP)	1659% (2911%)	1523% (2655%)
particulate matter formation; impact on human health	-83% (-60%)	-80% (-61%)
photochemical oxidant formation: human health; tropospheric ozone concentration increase	40% (85%)	31% (70%)
water use-user deprivation potential (deprivation-weighted water consumption)	-76% (-61%)	-56% (-44%)

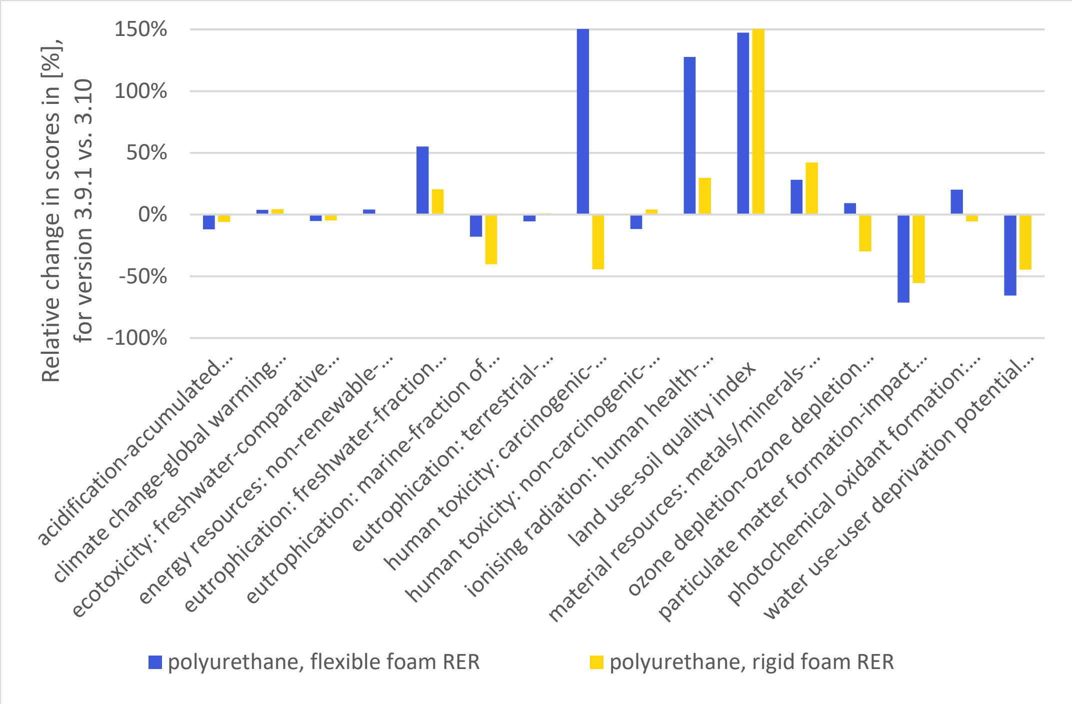

Figure 12. Comparison of relative change in scores (EF 3.1) between version 3.9.1 and 3.10 (system model: allocation, cut-off) for the activities "market for polyurethane, flexible foam" and "market for polyurethane, rigid foam" for the RER region.

Table 35 contains all datasets which were deleted from v3.9.1 and replaced with a new dataset in v3.10. **Table 36** lists datasets updated within the diisocyanate and polyol project.

Table 35. Replaced 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 v3.9.1	Product Name v3.9.1	Activity Name v3.10	Product Name v3.10	Geography	Time Period
polyol production	polyol	polyether polyols production, long chain	polyether polyols, long chain	GLO; RER	2020-2026
		polyether polyols production, short chain	polyether polyols, short chain	GLO; RER	2020-2026
market for polyol	polyol	market for polyether polyols, long chain	polyether polyols, long chain	GLO; RER	2023-2023
		market for polyether polyols, short chain	polyether polyols, short chain	GLO; RER	2023-2023

Table 36. New and updated 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 “v3.10”, “N” stands for “New Activity”, “U” stands for "Updated Activity”.

Activity Name in v3.10	Geography	Time Period	Product Name	Unit	v3.10
methylene diphenyl diisocyanate production	GLO; RER	2020-2026	methylene diphenyl diisocyanate	kg	U
toluene diisocyanate production	GLO: RER	2020-2026	toluene diisocyanate	kg	U
market for toluene diisocyanate, ISOPA	RER	2020-2026	toluene diisocyanate, ISOPA	kg	N
market for polyether polyols, short chain, ISOPA	RER	2020-2026	polyether polyols, short chain, ISOPA	kg	N
market for polyether polyols, long chain, ISOPA	RER	2020-2026	polyether polyols, long chain, ISOPA	kg	N
market for methylene diphenyl diisocyanate, ISOPA	RER	2020-2026	methylene diphenyl diisocyanate, ISOPA	kg	N
polyether polyols production, long chain, ISOPA	RER	2020-2025	polyether polyols, long chain, ISOPA	kg	N
polyether polyols production, short chain, ISOPA	RER	2020-2026	polyether polyols, short chain, ISOPA	kg	N
toluene diisocyanate production, ISOPA	RER	2020-2026	toluene diisocyanate, ISOPA	kg	N
methylene diphenyl diisocyanate production, ISOPA	RER	2020-2026	methylene diphenyl diisocyanate, ISOPA	kg	N

4.7 Inclusion of industrial cooling supply

This update aims to expand the database coverage for industrial services. Namely, several datasets for cooling supply for process streams at temperatures well below ambient, i.e., –15, –25, –45, –55, –100, and –160 °C are introduced. Currently, the cooling supply activities contribute only to the activities related to producing light olefins from methanol. To broaden the modularity of data in the chemical sector and classification of cooling supply, an investigation is planned for the following releases. **Table 37** contains a list of all added activities for cooling cycles.

Table 37. New datasets in v3.10.

Activity Name in v3.10	Geography	Time Period	Product Name	Unit
cooling energy production, at -100 °C, R-134a-carbon dioxide-ethylene compression refrigeration system 1 MW	GLO	2017-2022	cooling energy, at -100 °C	MJ
cooling energy production, at -100 °C, propylene-ethylene compression refrigeration system 1 MW	GLO	2017-2022	cooling energy, at -100 °C	MJ
cooling energy production, at -15 °C, R-134a compression refrigeration system 1 MW	GLO	2017-2022	cooling energy, at -15 °C	MJ
cooling energy production, at -160 °C, propylene-ethylene-methane compression refrigeration system 1 MW	GLO	2017-2022	cooling energy, at -160 °C	MJ
cooling energy production, at -25 °C, ammonia compression refrigeration system 1 MW	GLO	2017-2022	cooling energy, at -25 °C	MJ
cooling energy production, at -25 °C, propylene compression refrigeration system 1 MW	GLO	2017-2022	cooling energy, at -25 °C	MJ
cooling energy production, at -45 °C, R-134a compression refrigeration system 1 MW	GLO	2017-2022	cooling energy, at -45 °C	MJ
cooling energy production, at -45 °C, propylene compression refrigeration system 1 MW	GLO	2017-2022	cooling energy, at -45 °C	MJ
cooling energy production, at -55 °C, propylene-ethylene compression refrigeration system 1 MW	GLO	2017-2022	cooling energy, at -55 °C	MJ
market for cooling energy, at -100 °C	GLO	2017-2022	cooling energy, at -100 °C	MJ
market for cooling energy, at -15 °C	GLO	2017-2022	cooling energy, at -15 °C	MJ
market for cooling energy, at -160 °C	GLO	2017-2022	cooling energy, at -160 °C	MJ
market for cooling energy, at -25 °C	GLO	2017-2022	cooling energy, at -25 °C	MJ
market for cooling energy, at -45 °C	GLO	2017-2022	cooling energy, at -45 °C	MJ
market for cooling energy, at -55 °C	GLO	2017-2022	cooling energy, at -55 °C	MJ

4.8 Unit processes balance revision

This update aims on revising the mass and energy balances for the activities listed in **Table 39**, based on literature data and stoichiometric calculations. Namely, the mass inputs and outputs are updated either partially, or entirely, based on a generic model developed to cover production activity data for chemicals. The data generated by this model are improved, if possible, with compound-specific and industry or literature data. Namely, in this update, energy inputs for the specific technologies are based on literature.

The basic principles of the model have been published in literature (Hischier, 2005), while it has also been updated with newly available data. In short, solvents and catalysts are mostly recycled in closed-loop systems and reported flows are for losses from such exchanges. Moreover, unreacted fractions are treated in a waste treatment process that is included in the scope of each activity, and emissions reported are after treatment. For volatile reactants, a small level of evaporation is assumed.

The range of relative changes in LCIA scores for selected indicators of the EF 3.1 method (as minimum, median, and maximum) observed for the European activities listed in **Table 39** are provided in **Table 38**.

Table 38. Comparison of relative change in scores (EF 3.1) between version 3.9.1 and v3.10 (system model: allocation, cut-off) for the activities reported in **Table 39** and for the RER geography (n=23).

LCIA impact category – EF 3.1	Minimum	Median	Maximum
acidification-accumulated exceedance (AE)	-41%	8%	98%
climate change-global warming potential (GWP100)	-26%	23%	60%
ecotoxicity: freshwater; comparative toxic unit for ecosystems (CTUe)	-87%	-16%	914%
energy resources: non-renewable; abiotic depletion potential (ADP): fossil fuels	-15%	16%	34%
eutrophication: freshwater; fraction of nutrients reaching freshwater end compartment (P)	-52%	26%	75%
eutrophication: marine; fraction of nutrients reaching marine end compartment (N)	-90%	-1%	26%
eutrophication: terrestrial; accumulated exceedance (AE)	-40%	8%	137%
human toxicity: carcinogenic; comparative toxic unit for human (CTUh)	395%	999%	2250%
human toxicity: non-carcinogenic; comparative toxic unit for human (CTUh)	-46%	17%	182%
ionising radiation: human health; human exposure efficiency relative to u235	-20%	12%	207%
land use; soil quality index	-74%	21%	147%
material resources: metals/minerals; abiotic depletion potential (ADP): elements (ultimate reserves)	-3%	18%	139%
ozone depletion; ozone depletion potential (ODP)	-91%	18%	708%
particulate matter formation; impact on human health	-60%	10%	146%
photochemical oxidant formation: human health; tropospheric ozone concentration increase	-30%	15%	266%
water use-user deprivation potential (deprivation-weighted water consumption)	-74%	-35%	76%

Table 39. List of updated 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 “v3.10”, “N” stands for “New Activity”, “U” stands for "Updated Activity”.

Activity Name in v3.10	Geography	Time Period	Product Name	Unit	v3.10
2-methyl-2-butanol production	GLO; RER	1989-2022	2-methyl-2-butanol	kg	U
N,N-dimethylformamide production, direct synthesis	GLO; RER	2003-2022	N,N-dimethylformamide	kg	U
acetaldehyde production, ethylene oxidation	GLO; RER	1989-2022	acetaldehyde	kg	U
acetic acid production, methanol carboxylation (Monsanto), product in 98% solution state	GLO; RER	1989-2022	acetic acid, without water, in 98% solution state	kg	U
acetic anhydride production, acetaldehyde oxidation	GLO; RER	1989-2022	acetic anhydride	kg	U
acetic anhydride production, acetic acid pyrolysis, via ketene intermediate	GLO; RER	1989-2022	acetic anhydride	kg	U
chlorosulfonic acid production	GLO; RER	2003-2022	chlorosulfonic acid	kg	U
cyclohexane production, benzene hydrogenation, liquid phase process	GLO; RER	1989-2022	cyclohexane	kg	U
dimethyl malonate production	GLO; RER	2003-2022	dimethyl malonate	kg	U
dimethylamine production	GLO; RER	2003-2022	dimethylamine	kg	U
maleic anhydride production by catalytic oxidation of benzene	GLO; RER	1999-2022	maleic anhydride	kg	U
maleic anhydride production by direct oxidation of n-butane	GLO; RER	1999-2022	maleic anhydride	kg	U
market for m-nitrotoluene	GLO	2003-2022	m-nitrotoluene	kg	N
market for o-nitrotoluene	GLO	2003-2022	o-nitrotoluene	kg	N
market for polycarbonate	RER	2011-2011	polycarbonate	kg	N
methylamine production	GLO; RER	2003-2022	methylamine	kg	U
methylcyclohexane production	GLO; RER	1989-2022	methylcyclohexane	kg	U
nitrotoluenes production, toluene nitration	CN; IN; US	2003-2022	m-nitrotoluene; o-nitrotoluene; p-nitrotoluene	kg; kg; kg	N
nitrotoluenes production, toluene nitration	GLO; RER	2003-2022	m-nitrotoluene; o-nitrotoluene; p-nitrotoluene	kg; kg; kg	U
phenol production, cumene oxidation	GLO; RER	2017-2022	phenol	kg	U
sodium cyanide production	GLO; RER	2003-2022	sodium cyanide	kg	U
sodium methoxide production	GLO	2003-2022	sodium methoxide	kg	U
thionyl chloride production	GLO; RER	2003-2022	thionyl chloride	kg	U

4.9 Harmonisation of proxy inputs

This update facilitates the proxy flows harmonisation used in a set of chemicals production activities that are listed in Annex 2: 'Chemicals: Harmonisation of proxy inputs' – list of updated datasets. The values and type of exchanges used for (1) electricity, medium voltage, (2) heat, district or industrial, natural gas, and (3) heat, from steam, in chemical industry, (4) chemical factory, organics, (5) wastewater, average, (6) Water: (i) cooling, (ii) river, (iii) well, in ground, (iv) to air, and (v) to water are harmonised. Finally, exchanges used for (1) compressed air, 1000 kPa gauge, (2) nitrogen, liquid, and (3) Nitrogen, to air, (4) tap water, and (5) water, unspecified natural origin are excluded.

4.10 Various updates

The dataset in **Table 40** was remodelled to reflect a heat production which produces 1 MJ of heat by burning the necessary input of coal tar instead of treatment of 1 kg of coal tar.

Table 40. Replaced dataset in v3.10.

Activity Name v3.9.1	Product Name v3.9.1	Activity Name v3.10	Product Name v3.10	Geography	Time Period
treatment of coal tar, in industrial furnace 1MW	heat, district or industrial, other than natural gas	heat production, coal tar, at industrial furnace 1MW	heat, district or industrial, other than natural gas	GLO	2000-2000

Listed in **Table 41** are datasets which were updated within v3.10. All updates were done to ensure proper modelling in the consequential system model.

Table 41. Updated 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 "v3.10", "U" stands for "Updated Activity".

Activity Name in v3.10	Geography	Time Period	Product Name	Unit	v3.10
1,3-dichloropropene to generic market for pesticide, unspecified	GLO	2012-2012	pesticide, unspecified	kg	U
market for 1,3-dichloropropene	GLO	2012-2012	1,3-dichloropropene	kg	U
market for coal tar	GLO	2012-2012	coal tar	kg	U

5 Electricity

5.1 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 2020 electricity mixes, based on primary data from the International Energy Agency (IEA). Canadian and US power grids were updated to represent the year 2021 due the availability of more recent data. Not included in this package are the electricity mixes in Brazil, India, Switzerland and China These were updated separately, based on national statistics (see Section 5.2).

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 reported electricity generation data for Venezuela [VE] of the International Energy Agency IEA is missing generation data for electricity from oil (International Energy Agency (IEA), 2023). Such data is available elsewhere at 9.80 TWh in 2020 (Our World in Data, 2023) and was added to the VE electricity mixes.

The following sections describe the changes performed for the update of the electricity market mixes. **Table 42** shows for which geographies the electricity market mixes were updated in the attributional system models.

Table 42. Updated electricity market 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
market for electricity, high voltage	AE; AL; AM; AO; AR; AT; AU; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; 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; UY; UZ; VE; VN; XK; YE; ZA; ZM; ZW	2020-2020	electricity, high voltage	kWh
market for electricity, high voltage	BR-North-eastern grid; BR-Northern grid; BR-Southern grid; BR-South-eastern/Mid-western grid; CH : 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; CN-CCG; CN-CSG; CN-ECGC; CN-NCGC; CN-NECG; CN-NWG; CN-SWG; IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid; US-ASCC; US-HICC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC; US-PR	2021-2021	electricity, high voltage	kWh
market for electricity, high voltage,	CH	2021-2021	electricity, high voltage,	kWh

renewable energy products			renewable energy products	
market for electricity, low voltage	AE; AL; AM; AO; AR; AT; AU; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; 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; UY; UZ; VE; VN; XK; YE; ZA; ZM; ZW	2020-2020	electricity, low voltage	kWh
market for electricity, low voltage	BR-North-eastern grid; BR-Northern grid; BR-Southern grid; BR-South-eastern/Mid-western grid; CH : 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; CN-CCG; CN-CSG; CN-ECGC; CN-NCGC; CN-NECG; CN-NWG; CN-SWG; IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid; US-ASCC; US-HICC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC; US-PR	2021-2021	electricity, low voltage	kWh
market for electricity, low voltage, renewable energy products	CH	2021-2021	electricity, low voltage, renewable energy products	kWh
market for electricity, medium voltage	AE; AL; AM; AO; AR; AT; AU; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; CD; CG; CI; CL; CM; 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; UY; UZ; VE; VN; XK; YE; ZA; ZM; ZW	2020-2020	electricity, medium voltage	kWh
market for electricity, medium voltage	BR-North-eastern grid; BR-Northern grid; BR-Southern grid; BR-South-eastern/Mid-western grid; CH ; CO; 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; CN-CCG; CN-CSG; CN-ECGC; CN-NCGC; CN-NECG; CN-NWG; CN-SWG; IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid; US-ASCC; US-HICC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC; US-PR	2021-2021	electricity, medium voltage	kWh
market for electricity, medium voltage, renewable energy products	CH	2021-2021	electricity, medium voltage, renewable energy products	kWh

5.1.1 New import and technology splits

Some electricity import origins were added because the respective imports were not included in previous versions of the ecoinvent database or some imports were missing. All the new splits are listed in the table below. Temporal inconsistencies may occur due to limited data availability. Also, please note that these splits are only used to distribute electricity imports that are not documented per import region in the primary data sources, so the resulting import mix per market might differ somewhat.

Please also note that there is a gap in Albanian [AL] trade data in 2020 in the OECD statistics. The imports to Albania could be covered as listed below, but potential exports from Albania to Serbia [RS] (which amounted to 2.2% of total Serbian imports) or Kosovo [XK] (with contribution of about 20% of domestic electricity supply (International Monetary Fund IMF, 2023)) were neglected due to the data gap. The influence on LCI and LCIA results is expected to be low in the case of Serbia due to the low share of these imports in earlier years, while the impact for the electricity mix of Kosovo may be substantially higher.

In addition, several electricity trade activities related to Costa Rica [CR] and Panama [PA] do not seem to be reported for 2020, but it remains unclear, too which extent this is justified or not. Electricity exports to CR and PA could be covered from trade data as listed below.

Table 43. 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
AL	2.7% electricity, high voltage, import from CZ 7.1% electricity, high voltage, import from GR 83.5% electricity, high voltage, import from RS 6.7% electricity, high voltage, import from SI	2020	(United Nations, 2023)
CR	93.6% electricity, high voltage, import from SV 6.4% electricity, high voltage, import from GT	2020	(United Nations, 2023)
PA	32.6% electricity, high voltage, import from SV 67.4% electricity, high voltage, import from GT	2020	(United Nations, 2023)
SA	100% electricity, high voltage, import from AE	2020	(United Nations, 2023)

Some 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 44. 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.

Geography	Fuel type	Technology split	Data years	Data source
GT	natural gas (non-CHP)	100% electricity production, natural gas, conventional power plant (limited amount of natural gas power generation and no reports of a newly opened plant is indicating that this might refer to small-scale co-combustion in existing plants which is modelled here with a conventional plant instead of combined cycle gas turbine, which are typically much larger in size)	N/A	N/A
BY	nuclear (total)	100% electricity production, nuclear, pressure water reactor (Ostrovets power plant that went into operation in 2020)	2023	(World Nucelar Associati on, 2023)
IL	solar thermal	50% electricity production, solar thermal parabolic trough, 50 MW 50% electricity production, solar tower power plant, 20 MW (based on the two types of plants at Ashalim that were inaugurated in 2019)	2023	(Wikipedi a, 2023)

5.1.2 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 45** lists all newly created import datasets with their respective origin and destination.

Table 45. New import activities for electricity.

Activity Name	Geography	Time Period	Product Name	Unit
electricity, high voltage, import from AL	XK	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from DE	BE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from DE	NO	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from GT	PA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from IT	ME	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from MD	UA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from NO	DE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from RLA	CR	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from RLA	PA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from RME	PA	2020-2020	electricity, high voltage	kWh

electricity, high voltage, import from RO	UA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from XK	AL	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from RME	SA	2020-2020	electricity, high voltage	kWh

5.2 National updates

5.2.1 Brazil

The Brazilian electricity markets were updated analogous to the procedure for v3.9 of the ecoinvent database and represent the year 2021 for v3.10. See the corresponding change report (https://ecoinvent.org/the-ecoinvent-database/data-releases/) for data sources and explanation.

5.2.2 China

The Chinese electricity markets were updated analogous to the procedure for v3.9 of the ecoinvent database and represent the year 2021 for v3.10. See the corresponding change report (https://ecoinvent.org/the-ecoinvent-database/data-releases/) for data sources and explanation.

5.2.3 India

The Indian electricity markets were updated analogous to the procedure for v3.9 of the ecoinvent database and represent the year 2020-21 for v3.10. See the corresponding change report (https://ecoinvent.org/the-ecoinvent-database/data-releases/) for data sources and explanation.

5.2.4 Switzerland

The Swiss electricity markets were updated analogous to the procedure for v3.8 of the ecoinvent database and represent the year 2021 for v3.9. See the corresponding change report (https://ecoinvent.org/the-ecoinvent-database/data-releases/) for data sources and explanation.

5.3 Time periods of market, transformation and import activities

Time periods for all electricity related activities in **Table 46** were updated to reflect the year for which the corresponding electricity market is considered valid. Meta fields such as the fields “General Comment”, “Included Activities Start”, “Included Activities End” and “Technology Comment” were harmonised among market, transformation and import activities.

Table 46. Activities with updated time periods and harmonised meta fields. 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
electricity voltage transformation from high to medium voltage	AE; AL; AM; AO; AR; AT; AU; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; 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; UY; UZ; VE; VN; XK; YE; ZA; ZM; ZW	2020-2020	electricity, medium voltage	kWh
electricity voltage transformation from high to medium voltage	US-PR	2021-2021	electricity, medium voltage	kWh
electricity voltage transformation from high to medium voltage	CN-CCG; CN-CSG; CN-ECGC; CN-NCGC; CN-NECG; CN-NWG; CN-SWG; IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid	2021-2021	electricity, medium voltage	kWh
electricity voltage transformation from high to medium voltage	BR-North-eastern grid; BR-Northern grid; BR-South-eastern/Mid-western grid; BR-Southern grid; 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; CH; US-ASCC; US-HICC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC	2021-2021	electricity, medium voltage	kWh
electricity voltage transformation from high to medium voltage, renewable energy products	CH	2021-2021	electricity, medium voltage, renewabl e energy products	kWh
electricity voltage transformation from medium to low voltage	AE; AL; AM; AO; AR; AT; AU; AZ; BA; BD; BE; BG; BH; BJ; BN; BO; BW; BY; 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; UY; UZ; VE; VN; XK; YE; ZA; ZM; ZW	2020-2020	electricity, low voltage	kWh
electricity voltage transformation from medium to low voltage	US-PR	2021-2021	electricity, low voltage	kWh
electricity voltage transformation from medium to low voltage	CN-CCG; CN-CSG; CN-ECGC; CN-NCGC; CN-NECG; CN-NWG; CN-SWG; IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid	2021-2021	electricity, low voltage	kWh
electricity voltage transformation from medium to low voltage	BR-North-eastern grid; BR-Northern grid; BR-South-eastern/Mid-western grid; BR-Southern grid; 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; CH; US-ASCC; US-HICC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC	2021-2021	electricity, low voltage	kWh

electricity voltage transformation from medium to low voltage, renewable energy products	CH	2021-2021	electricity, low voltage, renewable energy products	kWh
electricity voltage transformation, residual mix, from high to medium voltage	CH; IE	2021-2021	electricity, medium voltage	kWh
electricity voltage transformation, residual mix, from high to medium voltage	BA; BE; BG; CY; CZ; DE; DK; EE; ES; FI; FR; GB; GR; HR; HU; IS; IT; LT; LU; LV; ME; MT; NL; NO; PL; PT; RO; RS; SE; SI; SK	2022-2022	electricity, medium voltage	kWh
electricity voltage transformation, residual mix, from medium to low voltage	CH; IE	2021-2021	electricity, low voltage	kWh
electricity voltage transformation, residual mix, from medium to low voltage	BA; BE; BG; CY; CZ; DE; DK; EE; ES; FI; FR; GB; GR; HR; HU; IS; IT; LT; LU; LV; ME; MT; NL; NO; PL; PT; RO; RS; SE; SI; SK	2022-2022	electricity, low voltage	kWh
electricity, high voltage, hydro, reservoir, import from France	CH	2021-2021	electricity, high voltage	kWh
electricity, high voltage, hydro, run-of-river, import from France	CH	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from AL	GR; ME; RS	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from AO	CD	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from AR	BR-Southern grid	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from AT	CZ; DE; HU; IT; SI	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from BA	HR; ME; RS	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from BE	GB	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from BE	FR; LU; NL	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from BG	GR; MK; RO; RS; TR	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from BR-North-eastern grid	BR-Northern grid; BR-South-eastern/Mid-western grid	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from BR-Northern grid	BR-South-eastern/Mid-western grid	2021-2021	electricity, high voltage	kWh

electricity, high voltage, import from BR-South-eastern/Mid-western grid	BR-Southern grid	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from BR-Southern grid	AR	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from BT	IN-Eastern grid	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from BY	LT; UA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from CA-AB	CA-BC; CA-SK; US-WECC	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CA-BC	CA-AB; US-WECC	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CA-MB	CA-ON; CA-SK; US-MRO	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CA-NB	CA-NS; CA-PE; CA-QC; US-NPCC	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CA-NF	CA-QC	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CA-NS	CA-NB; US-NPCC	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CA-ON	GLO	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from CA-ON	CA-MB; CA-QC; US-NPCC	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CA-PE	CA-NB	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CA-QC	CA-NB; CA-NF; CA-ON	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CA-SK	CA-AB; US-MRO	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from CD	CG; GA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from CH	AT; DE; FR; IT; RO	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from CL	AR	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from CO	EC; VE	2020-2020	electricity, high voltage	kWh

electricity, high voltage, import from CR	NI; PA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from CZ	AT; DE; PL; SK	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from DE	BE; NO	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from DE	AT; CZ; DK; FR; LU; NL; PL; SE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from DK	NL	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from DK	DE; NO; SE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from DZ	MA; TN	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from EC	CO	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from EE	FI; LV	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from EG	SD	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from ES	FR; PT	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from FI	EE; NO; RU; SE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from FR	BE; DE; ES; GB; IT; LU	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from GB	FR; IE; NL	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from GE	AM; AZ; TR	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from GH	TG	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from GR	AL; BG; IT; MK; TR	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from GT	MX; SV	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from HN	GT	2020-2020	electricity, high voltage	kWh

electricity, high voltage, import from HR	BA; HU; RS; SI	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from HU	AT; HR; RO; RS; SK; UA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from ID	MY	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from IE	GB	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from IR	IQ	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from IT	AT; FR; GR; SI	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from KZ	UZ	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from LT	BY; LV; PL; RU; SE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from LU	BE; DE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from LV	EE; LT	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from MA	DZ	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from ME	AL; BA; IT; RS	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from MK	BG; GR; RS	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from MX	GT	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from MX	US-TRE; US-WECC	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from MY	ID	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from MZ	TZ; ZA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from NG	BJ; NE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from NI	HN	2020-2020	electricity, high voltage	kWh

electricity, high voltage, import from NL	DK	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from NL	BE; DE; GB; NO	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from NO	DK; FI; NL; SE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from PA	CR	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from PL	CZ; DE; LT; SE; SK	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from PT	ES	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from PY	BR-South-eastern/Mid-western grid; BR-Southern grid	2021-2021	electricity, high voltage	kWh
electricity, high voltage, import from RLA	CR; PA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from RME	PA; SA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from RO	BG; HU; MD; RS	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from RS	AL; BA; BG; HR; HU; ME; MK; RO; XK	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from RU	BY; FI; LT; LV; NO; UA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from SA	BH; JO	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from SE	DE; DK; FI; LT; NO; PL	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from SI	AT; HR; IT	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from SK	CZ; HU; PL; UA	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from SY	LB	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from TG	GH	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from TN	LY	2020-2020	electricity, high voltage	kWh

electricity, high voltage, import from TR	BG; GR; IR; SY	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from TZ	KE	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from UA	BY; HU; MD; PL; RO; SK	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from US-NPCC	GLO	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from UY	BR-Southern grid	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from UZ	KG; KZ; TJ	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from VE	CO	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from VN	KH	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from ZA	BW; MZ; NA; ZW	2020-2020	electricity, high voltage	kWh
electricity, high voltage, import from ZW	ZM	2020-2020	electricity, high voltage	kWh
electricity, high voltage, natural gas, import from Germany	CH	2021-2021	electricity, high voltage	kWh

5.4 New European markets for transmission infrastructure

Three new European (RER) markets were added to the database. These markets are supplied by their corresponding RER producers and all electricity markets enclosed in RER are connected to them. **Table 47** lists the newly added markets.

Table 47. New markets for transmission infrastructure.

Activity Name	Geography	Time Period	Product Name	Unit
market for transmission network, electricity, high voltage direct current aerial line	RER	1998-2012	transmission network, electricity, high voltage direct current aerial line	km
market for transmission network, electricity, high voltage direct current land cable	RER	1998-2012	transmission network, electricity, high voltage direct current land cable	km
market for transmission network, electricity, high voltage direct current subsea cable	RER	1998-2012	transmission network, electricity, high voltage	km

			direct current subsea cable	

5.5 Residual mixes

The European electricity residual mix markets were updated analogous to the procedure for v3.9 of the ecoinvent database and represent the year 2022 for v3.10. See the corresponding change report (https://ecoinvent.org/the-ecoinvent-database/data-releases/) for data sources and explanation.

5.6 Small-scale wind turbine

New datasets on a 6kW small-scale wind turbine were introduced in v3.10 of the ecoinvent database. The data was provided by the author of the thesis "Development of the data basis for Integration of small wind turbines in Life cycle assessment based energy system models" (translated) (Knausenberger, 2022). The newly added datasets are listed in **Table 48**.

Table 48. New datasets for the small-scale wind turbine. 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
electricity production, wind, 6kW small-scale turbine, onshore	DE	2013-2022	electricity, low voltage	kWh
market for wind turbine network connection, small-scale, 6kW, onshore	DE	2013-2022	wind turbine network connection, small-scale, 6kW, onshore	unit
market for wind turbine, small-scale, 6kW, onshore	DE	2013-2022	wind turbine, small-scale, 6kW, onshore	unit
wind turbine construction, small-scale, 6kW, onshore	DE	2013-2022	wind turbine, small-scale, 6kW, onshore	unit
wind turbine network connection construction, small-scale, 6kW, onshore	DE	2013-2022	wind turbine network connection, small-scale, 6kW, onshore	unit

5.7 Various updates

5.7.1 Correction: electricity production, deep geothermal

The amount of the exchange "Energy, geothermal, converted" in the datasets listed in Table 49 was corrected due to a missing conversion factor converting the amount from kWh to MJ.

Table 49. Corrected datasets for geothermal electricity. 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
electricity production, deep geothermal	CH; CR; DE; GLO; ID; IS; IT; JP; KE; MX; NI; NZ; PH; PT; RU; SV; TH; TR; US-HICC; US-WECC	2015-2015	electricity, high voltage	kWh
electricity production, deep geothermal	CL; CN-GD; CN-SH; CZ; FR; GB; HU; IN-TN; LT; LV; PL; US-SERC; ZA	2016-2018	electricity, high voltage	kWh

5.7.2 Correction: electricity production, natural gas

For all datasets in Table 50 the mathematical formula responsible for calculating the input amount of natural gas has been recalculated.

Table 50. Corrected datasets for electricity production from natural gas. 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
electricity production, natural gas, combined cycle power plant	AT; AU; BE; CA-AB; CA-BC; CA-MB; CA-NB; CA-NS; CA-NT; CA-ON; CA-SK; CL; CN-AH; CN-BJ; CN-CQ; CN-FJ; CN-GD; CN-GS; CN-GX; CN-GZ; CN-HA; CN-HB; CN-HE; CN-HL; CN-HN; CN-HU; CN-JL; CN-JS; CN-JX; CN-LN; CN-NM; CN-NX; CN-QH; CN-SA; CN-SC; CN-SD; CN-SH; CN-SX; CN-TJ; CN-XJ; CN-XZ; CN-YN; CN-ZJ; CZ; DE; ES; FI; FR; GB; GLO; GR; HR; HU; ID; IE; IR; IT; JP; KR; MX; MY; NO; PT; SA; SK; TH; TR; TW; UA; US-ASCC; US-MRO; US-NPCC; US-RFC; US-SERC; US-TRE; US-WECC	2000-2015	electricity, high voltage	kWh
electricity production, natural gas, combined cycle power plant	BR-North-eastern grid; BR-Northern grid; BR-Southern grid; CO	2014-2017	electricity, high voltage	kWh
electricity production, natural gas, combined cycle power plant	BG; CH; CY; LU; LV; MT; NL; PL; RO; RU; SE; SI; ZA	2016-2018	electricity, high voltage	kWh
electricity production, natural gas, conventional power plant	AU; CA-AB; CA-BC; CA-MB; CA-NB; CA-NF; CA-NS; CA-NT; CA-ON; CA-PE; CA-SK; CL; CN-AH; CN-BJ; CN-CQ; CN-FJ; CN-GD; CN-GS; CN-GX; CN-GZ; CN-HA; CN-HB; CN-HE; CN-HL; CN-HN; CN-HU; CN-JL; CN-JS; CN-JX; CN-LN; CN-NM; CN-NX; CN-QH; CN-SA; CN-SC; CN-SD; CN-SH; CN-SX; CN-TJ; CN-XJ; CN-XZ; CN-YN; CN-ZJ; GLO; ID; IR; KR; MX; MY; RU; SA; TH; TR; TW; TZ; UA	1990-2015	electricity, high voltage	kWh

6 Wastes

Version 3.10 introduces updates and methodological changes to the waste sector.

6.1 Waste aggregation and disaggregation

The waste sector in the ecoinvent database comprises of more than 3000 datasets, covering the management of wastes and wastewaters from a wide variety of sectors producing them. The sector can be subdivided into solid waste management (SWM) and wastewater treatment (WWT).

When a waste is generated, it naturally passes several treatment steps and potentially more wastes (apart from this waste) are generated until the original waste is finally disposed. For example, municipal solid waste that is treated in a waste incineration is generating other wastes such as bottom ass and other incineration residues which in turn require treatment.

Up to and including version 3.8 the waste sector featured “waste aggregation”. In practice, a single treatment dataset at the ecoinvent database handled the treatment of a waste, and all treatments for wastes generated by this waste. Consequently, a waste treatment process was an aggregation of treatments.

In v.3.9 the disaggregation of treatments was introduced for the first time in the database, covering the wastewater sector. In effect, all wastewater treatment activities were disaggregated into different treatments for all the wastes generated during the wastewater treatment.

Likewise, in v.3.10, the disaggregation of treatments is completed by introducing the disaggregated datasets for municipal incineration and sanitary landfill. Meaning all incineration and sanitary landfill treatment activities are now disaggregated into the different treatment steps for wastes generated during these treatments.

6.1.1 Naming convention

In v.3.9, a new naming convention was introduced in the sector to enhance clarity for new and updated datasets. This naming convention is now in v.3.10 methodically applied in the whole waste sector of the database.

6.1.1.1 Waste treatment activity names

All new treatment activity names have three elements,

a) the term introducing that this activity is a treatment

b) the name of the waste or wastewater (details also in section Waste or wastewater names)

c) and a suffix that clearly defines the treatment process

For example, “treatment of municipal solid waste, municipal incineration”

The naming convention allows users to efficiently look for:

a) all available treatment options for a specific waste or wastewater by searching using the name of the waste (e.g., municipal solid waste)

b) all wastes treated by a specific treatment by searching using the term of the treatment (e.g., municipal incineration)

c) all treatment activities by searching using the term of the treatment (e.g., treatment of…)

6.1.1.2 Waste or wastewater names

The disaggregation inevitably generates new wastes within the database and their names are designed in a manner to reflect the waste treatment chain.

The new names of the waste or wastewater generated due to disaggregation have three elements:

a) The name of the waste itself

b) The treatment chain this waste was generated from. Here only the treatments are reported in capital letters separated with a dash (-)

c) The original waste or wastewater name in the beginning of the treatment chain

For example: "bottom ash, MSWI[F]-WWT-SLF, municipal solid waste" where a= bottom ash, b= MSWI[F]-WWT-SLF, and c= municipal solid waste.

List of abbreviations in treatment chains, within the waste name

- MSWI: Municipal solid waste incineration
- MSWI[F]: Municipal solid waste incineration, with fly ash extraction
- WWT: Wastewater treatment
- WWT[R]: Wastewater treatment, urban
- WWT[U]: Wastewater treatment, rural
- WW: Wastewater
- SLF: Sanitary landfill
- SLF[W]: Sanitary landfill, wet infiltration
- FAE: Fly ash extraction
- LDPE: Light density polyethylene
- LDPE/Alu: Mixture of LDPE and Aluminium

Table 51 shows all the names of the wastes affected by the waste disaggregation and how they are generated and treated in the database.

6.1.2 Municipal incineration and new datasets

Incineration of wastes, inevitably generates additional waste by-products; those by-products are: a) bottom ash and b) residues. Amount and elemental composition of those by-products are variable and dependent on the elemental composition of the original waste that entered the incineration treatment. Both by-products are disposed in a form of landfill, with bottom ash treated in slag compartment landfill whereas residues are treated in a residual material landfill.

6.1.3 Sanitary landfill and new datasets

Landfilling of wastes generates as well further wastes and/or by-products. First, certain wastes have a capacity to generate biogas which in turn is combusted as a best available technique to reduce methane emissions, and at the same time generates energy. Therefore, energy can be seen as by-produced from sanitary landfill datasets. Energy is of course as well consumed within the boundaries of the landfill and therefore, the energy by-production refers to the net energy that exits the system boundary of the treatment.

Leachate is collected the first years of operation of the landfill, and it is sent to a wastewater treatment plant. Like the wastes mentioned above from incineration; elemental composition of the leachate is variable and dependent on the elemental composition of the waste that was disposed in the landfill.

6.1.4 Wastewater balance

Incorrect water balances in wastewater treatment datasets are restored. In these processes, the amount of water released to the Environment, sub-compartment of ‘surface water’, was reduced to balance out the amount of water input entering the process. This update mostly affects datasets modelled in the global (GLO) geography, while it is almost negligible in the regional ones.

Table 51. New and updated wastes and wastewaters in version 3.10. SC: Slag compartment, RML: Residual material landfill, MSWI: Municipal solid waste incineration, SLF: Sanitary landfill, LF: Landfarming, WWT: Wastewater treatment, OD: Open dumping, UL: Unsanitary landfill, OB: Open burning, L: Remodelled and N: New waste due to disaggregation. The letters in the table—T, G, and Y—stand for treated, generated and yes, respectively.

Waste	SC	RML	MSWI	SLF	LF	WWT	OD	UL	OB	L	N
aluminium in car shredder residue			T							Y	
antimony slag, desulfurised		T								Y	
antimony slag, water-quenched		T								Y	
ash from deinking sludge		T								Y	
ash from paper production sludge		T								Y	
average incineration residue		T								Y	
basic oxygen furnace dust		T								Y	

Waste	SC	RML	MSWI	SLF	LF	WWT	OD	UL	OB	L	N
basic oxygen furnace secondary metallurgy slag		T								Y	
basic oxygen furnace slag		T								Y	
basic oxygen furnace sludge		T								Y	
basic oxygen furnace waste		T								Y	
biowaste			T				T			Y	
blast furnace dust		T								Y	
blast furnace slag		T								Y	
blast furnace sludge		T								Y	
coating from waste cathode ray tube display			T							Y	
copper in car shredder residue			T							Y	
copper slag		T								Y	
decarbonising waste		T								Y	
digester sludge			T							Y	
drilling waste		T								Y	
dross from Al electrolysis		T								Y	
electric arc furnace dust		T								Y	
electric arc furnace secondary metallurgy slag		T								Y	
electric arc furnace slag		T								Y	
filter dust from Al electrolysis		T								Y	
green liquor dregs		T								Y	
H3PO4 purification residue		T								Y	
hard coal ash		T	T	T						Y	
inert waste				T						Y	
leachate, SLF, [waste name]				G		T					Y
leachate, SLF[W], [waste name]				G		T					Y
lead in car shredder residue			T							Y	
lead smelter slag		T								Y	
lignite ash			T	T						Y	
mill scale		T								Y	
municipal solid waste			T	T			T	T	T	Y	
nickel smelter slag		T								Y	

Waste	SC	RML	MSWI	SLF	LF	WWT	OD	UL	OB	L	N
pollutant from rail ballast		T								Y	
raw sewage sludge			T							Y	
redmud from bauxite digestion		T								Y	
refinery sludge				T						Y	
refractory spent pot liner from Al electrolysis		T								Y	
residue from cooling tower				T						Y	
residue from mechanical treatment, cathode ray tube display	T							Y			
residue from mechanical treatment, desktop computer	T							Y			
residue from mechanical treatment, industrial device		T							Y		
residue from mechanical treatment, IT accessory		T							Y		
residue from mechanical treatment, laptop computer		T							Y		
residue from mechanical treatment, laser printer		T							Y		
residue from mechanical treatment, liquid crystal display	T							Y			
residue from Na-dichromate production		T								Y	
residue from rutile production, synthetic, 56% water	T								Y		
residue from shredder fraction from manual dismantling	T							Y			
residue from TiO2 production, chloride process		T								Y	
residue from TiO2 production, sulfate process		T								Y	
salt tailing from potash mine		T								Y	
scrap aluminium			T							Y	
scrap copper			T							Y	
scrap steel			T							Y	
scrap tin sheet			T	T						Y	
sewage sludge, 70% water, WWT-SLF, [waste name]		T	G							Y	
sewage sludge, 70% water, WWT-SLF[W], [waste name]	T	G							Y		
sewage sludge, 97% water, WWT-SLF, [waste name]			G	T						Y	
sewage sludge, 97% water, WWT-SLF[W], [waste name]		G	T						Y		
sludge from pulp and paper production				T						Y	

Waste	SC	RML	MSWI	SLF	LF	WWT	OD	UL	OB	L	N
sludge from steel rolling		T								Y	
sludge, NaCl electrolysis		T								Y	
sludge, NaCl electrolysis Hg		T								Y	
spent anion exchange resin from potable water production	T							Y			
spent catalyst base from ethyleneoxide production	T								Y		
spent cation exchange resin from potable water production	T							Y			
spent Formox catalyst base from formaldehyde production	T								Y		
spent pot liner from Al electrolysis, carbon fraction	T								Y		
steel in car shredder residue			T							Y	
tin slag		T								Y	
used liquid crystal display module			T							Y	
waste aluminium				T						Y	
waste asphalt				T						Y	
waste bamboo residues									T	Y	
waste bitumen				T						Y	
waste bitumen sheet			T							Y	
waste building wood, chrome preserved			T							Y	
waste cement, hydrated		T								Y	
waste cement-fibre slab, dismantled			T							Y	
waste emulsion paint			T	T						Y	
waste expanded polystyrene			T							Y	
waste frit from cathode ray tube production		T								Y	
waste glass			T	T			T	T	T	Y	
waste graphical paper			T	T			T	T	T	Y	
waste gypsum				T						Y	
waste newspaper			T	T						Y	
waste packaging paper			T	T			T	T	T	Y	
waste paint			T	T						Y	
waste paperboard			T	T			T	T	T	Y	
waste plastic plaster, for final disposal				T						Y	

Waste	SC	RML	MSWI	SLF	LF	WWT	OD	UL	OB	L	N
waste plastic, consumer electronics			T	T				T	T	Y	
waste plastic, industrial electronics			T							Y	
waste plastic, mixture			T	T			T	T	T	Y	
waste polyethylene			T	T			T	T	T	Y	
waste polyethylene terephthalate			T	T			T	T	T	Y	
waste polypropylene			T	T			T	T	T	Y	
waste polystyrene			T	T			T	T	T	Y	
waste polyurethane			T	T			T	T	T	Y	
waste polyvinylchloride			T	T			T	T	T	Y	
waste polyvinylfluoride			T							Y	
waste rubber, unspecified			T							Y	
waste sealing sheet, polyethylene			T							Y	
waste sealing sheet, polyvinylchloride			T							Y	
waste textile, soiled			T							Y	
waste vapour barrier, flame-retarded			T							Y	
waste wire plastic			T							Y	
waste wood pole, chrome preserved			T							Y	
waste wood, untreated			T	T			T	T	T	Y	
waste yarn and waste textile								T		Y	
waste, from silicon wafer production, inorganic		T								Y	
wood ash mixture, pure			T	T						Y	
zinc in car shredder residue			T							Y	
zinc slag		T								Y	
bottom ash, MSWI, [name of the waste]	T		G								Y
bottom ash, MSWI[F], [name of the waste]	T		G								Y
bottom ash, MSWI[F]-WWT-SLF, [name of the waste]	T			G							Y
bottom ash, MSWI-WWT-SLF, [name of the waste]	T			G							Y
residues, MSWI[F]-WWT-SLF, [name of the waste]	T		G							Y	
residues, MSWI-WWT-SLF, [name of the waste]		T		G							Y

Waste	SC	RML	MSWI	SLF	LF	WWT	OD	UL	OB	L	N
residues, MSWI, [name of the waste]		T	G								Y
residues, MSWI[F], [name of the waste]		T	G								Y

6.2 Biogas

In the context of a project funded by FOGA (Forschungs-, Entwicklungs- und Förderungsfonds der schweizerischen Gasindustrie) and Ökostrom Schweiz (Dinkel & Kägi, 2022), the inventory for Swiss agricultural biogas production based on manure was updated. The global version of this data set was extrapolated from the Swiss dataset, but without using activity links.

Updated datasets related to containerboard production are shown in **Table 52**.

Table 52: New and updated activities related to biogas.

Activity Name	Geography	Time Period	Product Name	Unit
anaerobic digestion of manure	CH; GLO	2018-2020	biogas	m3

7 Agriculture

7.1 Introduction

This chapter covers the changes to the ecoinvent database between version 3.9.1and version 3.10 for the Agriculture. Fishery & Animal Husbandry Sector in ecoinvent. It describes changes in the sector which consist in the addition of new datasets, in the deletion of outdated ones, and in the update, re-modelling, or corrections, of others.

7.2 New data for Australia (AU)

The update was performed in collaboration with LifeCycles and resulted in the addition of new products for Australia specifically. The new agricultural products are five, namely: barley grain; maize grain; oat grain; rape seed; and wheat grain. The new products are available for different states of Australia (AU), namely: New South Wales (NSW); Queensland (QLD); South Australia (SA); Tasmania (TAS); Victoria (VIC); Western Australia (WA) (some of the crops are available only in some of the above-mentioned regions). Finally, five new field operations for the country of Australia are added, namely: application of plant protection product by field sprayer; combined harvesting; fertilizing by broadcaster; planting with starter fertiliser by no-till planter; tillage cultivating chiselling. All new datasets for agriculture in Australia are reported in detail in **Table 53**.

Table 53. New activities added for v3.10, related to Australian agricultural production.

Activity Name	Geography	Time Period	Product Name	Unit
application of plant protection product, by field sprayer	AU	2010-2023	application of plant protection product, by field sprayer	ha
barley grain production	AUS-NSW	2011-2016	barley grain	kg
barley grain production	AUS-QLD	2011-2016	barley grain	kg
barley grain production	AUS-SA	2011-2016	barley grain	kg
barley grain production	AUS-TAS	2011-2016	barley grain	kg
barley grain production	AUS-VIC	2011-2016	barley grain	kg
barley grain production	AUS-WA	2011-2016	barley grain	kg
combine harvesting	AU	2012-2023	combine harvesting	ha
fertilizing, by broadcaster	AU	2012-2023	fertilising, by broadcaster	ha
maize grain production	AUS-NSW	2011-2016	wheat grain	kg
maize grain production	AUS-QLD	2011-2016	wheat grain	kg
maize grain production	AUS-VIC	2011-2016	wheat grain	kg
oat grain production	AUS-NSW	2011-2016	oat grain	kg
oat grain production	AUS-QLD	2011-2016	oat grain	kg

Activity Name	Geography	Time Period	Product Name	Unit
oat grain production	AUS-SA	2011-2016	oat grain	kg
oat grain production	AUS-TAS	2011-2016	oat grain	kg
oat grain production	AUS-VIC	2011-2016	oat grain	kg
oat grain production	AUS-WA	2011-2016	oat grain	kg
planting with starter fertiliser, by no till planter	AU	2012-2023	planting with starter fertiliser, by no till planter	ha
rape seed production	AUS-NSW	2011-2016	rape seed	kg
rape seed production	AUS-QLD	2011-2016	rape seed	kg
rape seed production	AUS-SA	2011-2016	rape seed	kg
rape seed production	AUS-VIC	2011-2016	rape seed	kg
rape seed production	AUS-WA	2011-2016	rape seed	kg
tillage, cultivating, chiselling	AU	2012-2023	tillage, cultivating, chiselling	ha
wheat grain production	AUS-NSW	2011-2016	wheat grain	kg
wheat grain production	AUS-QLD	2011-2016	wheat grain	kg
wheat grain production	AUS-SA	2011-2016	wheat grain	kg
wheat grain production	AUS-TAS	2011-2016	wheat grain	kg
wheat grain production	AUS-VIC	2011-2016	wheat grain	kg
wheat grain production	AUS-WA	2011-2016	wheat grain	kg

The activities reported in **Table 54** have been deleted and replaced with new specific state geographies for the country of Australia (AU) reported in **Table 53**. This has allowed for greater granularity of data and increased regionalization of the inventory for the specified crops. The markets have been updated accordingly.

Table 54. Activities replaced in the database with new granular datasets in v3.10, related to Australia production.

Activity Name	Geography	Time Period	Product Name	Unit
wheat production	AU	2009-2012	wheat grain	kg

7.3 New data for the United States (US)

The update was performed in collaboration with EarthShift Global and resulted in the addition of new products for the United States. The new agricultural products are four, namely: maize grain; potato, sweet corn, and soybean. The new products are available for different states in the US, namely: California (US-CA); Colorado (US-CO); Florida (US-FL); Idaho (US-ID); Illinois (US-IL); Indiana (US-IN); Iowa (US-IA); Maryland (US-MD); Minnesota (US-MN); Nebraska (US-NE); North Dakota (US-ND); Ohio (US-OH); Oregon (US-OR); South Dakota (US-SD); Washington (US-WA), and Wisconsin (US-WI) (some of the crops are available only in some of the above-mentioned regions). Finally, 42 new field operations for the US were added. All new products are reported in detail in **Table 55**.

Table 55. New activities added for v3.10, related to United States production.

Activity Name	Geography	Time Period	Product Name	Unit
aircraft production, agricultural	GLO	2021-2022	aircraft, production	unit
application of plant protection product, by airplane	US	2021-2022	application of plant protection product, by airplane	ha
application of plant protection product, by filed sprayer	US	2021-2022	application of plant protection product, by airplane	ha
application of plant protection product, fumigation	US	2021-2022	application of plant protection product, fumigation	ha
combine harvesting, maize	US	2021-2022	combine harvesting, maize	ha
combine harvesting, soybean	US	2021-2022	combine harvesting, soybean	ha
combine harvesting, sweet corn	US	2021-2022	combine harvesting, sweet corn	ha
combine harvesting	US	2021-2022	combine harvesting	ha
fertilising, by broadcaster	US	2021-2022	fertilising, by broadcaster	ha
fertilising, by injection	US	2021-2022	fertilising, by injection	ha
harvesting, by potato harvester	US	2021-2022	harvesting, by potato harvester	ha
harvesting, by sweet corn picker	US	2021-2022	harvesting, by sweet corn picker	ha
harvesting, use of harvesting cart	US	2021-2022	harvesting, use of harvesting cart	kg
liquid manure spreading, by vacuum tanker	US	2021-2022	liquid manure spreading, by vacuum tanker	m3
maize grain production	US-IA	2014-2021	maize grain	kg
maize grain production	US-IL	2014-2021	maize grain	kg
maize grain production	US-IN	2014-2021	maize grain	kg
maize grain production	US-MN	2014-2021	maize grain	kg

Activity Name	Geography	Time Period	Product Name	Unit
maize grain production	US-NE	2014-2021	maize grain	kg
maize grain production	US-SD	2014-2021	maize grain	kg
maize grain production	US-WI	2014-2021	maize grain	kg
mowing, by rotary or sickle mower	US	2021-2022	mowing, by rotary or sickle mower	ha
planting, by drill	US	2021-2022	planting, by drill	ha
planting, by no till drill	US	2021-2022	planting, by no till drill	ha
planting, by no till planter	US	2021-2022	planting, by no till planter	ha
planting, by ridge planter	US	2021-2022	planting, by ridge planter	ha
planting, by row crop planter	US	2021-2022	planting, by row crop planter	ha
planting, potato	US	2021-2022	planting, potato	ha
planting with starter fertiliser or amendment, by drill	US	2021-2022	planting with starter fertiliser or amendment, by drill	ha
planting with starter fertiliser or amendment, by no till planter	US	2021-2022	planting with starter fertiliser or amendment, by no till planter	ha
planting with starter fertiliser or amendment, by row crop planter	US	2021-2022	planting with starter fertiliser or amendment, by row crop planter	ha
planting with starter fertiliser or amendment, by subsoiler/v-ripper planter	US	2021-2022	planting with starter fertiliser or amendment, by subsoiler/v-ripper planter	ha
potato grading	US	2021-2022	potato grading	ha
potato production	US-CO	2010-2021	potato	kg
potato production	US-ID	2010-2021	potato	kg
potato production	US-MN	2010-2021	potato	kg
potato production	US-ND	2010-2021	potato	kg
potato production	US-OR	2010-2021	potato	kg
potato production	US-WA	2010-2021	potato	kg
potato production	US-WI	2010-2021	potato	kg
solid manure loading and spreading, by hydraulic loader and spreader	US	2021-2022	solid manure loading and spreading, by hydraulic loader and spreader	kg
soybean production	US-IA	2014-2021	soybean	kg
soybean production	US-IL	2014-2021	soybean	kg
soybean production	US-IN	2014-2021	soybean	kg
soybean production	US-MN	2014-2021	soybean	kg

Activity Name	Geography	Time Period	Product Name	Unit
soybean production	US-ND	2014-2021	soybean	kg
soybean production	US-NE	2014-2021	soybean	kg
soybean production	US-OH	2014-2021	soybean	kg
stalk shredding	US	2021-2022	stalk shredding	ha
swath, by rotary windrower	US	2021-2022	swath, by rotary windrower	ha
sweet corn production	US-CA	2014-2021	sweet corn	kg
sweet corn production	US-FL	2014-2021	sweet corn	kg
sweet corn production	US-MN	2014-2021	sweet corn	kg
sweet corn production	US-OR	2014-2021	sweet corn	kg
sweet corn production	US-WA	2014-2021	sweet corn	kg
sweet corn production	US-WI	2014-2021	sweet corn	kg
tillage, cultivating, by strip tiller	US	2021-2022	tillage, cultivating, by strip tiller	ha
tillage, cultivating, chiselling	US	2021-2022	tillage, cultivating, chiselling	ha
tillage, disking	US	2021-2022	tillage, disking	ha
tillage, disking, with amendment	US	2021-2022	tillage, disking, with amendment	ha
tillage, field cultivator	US	2021-2022	tillage, field cultivator	ha
tillage, field cultivator with amendment	US	2021-2022	tillage, field cultivator with amendment	ha
tillage, harrowing, by moldboard plow	US	2021-2022	tillage, harrowing, by moldboard plow	ha
tillage, harrowing, by offset disc harrow	US	2021-2022	tillage, harrowing, by offset disc harrow	ha
tillage, harrowing, by offset leveling disc harrow	US	2021-2022	tillage, harrowing, by offset leveling disc harrow	ha
tillage, harrowing, by tandem disk	US	2021-2022	tillage, harrowing, by tandem disk	ha
tillage, ridge cultivator	US	2021-2022	tillage, ridge cultivator	ha
tillage, rotary cultivator	US	2021-2022	tillage, rotary cultivator	ha
tillage, subsoiling, by subsoiler or v-ripper	US	2021-2022	tillage, subsoiling, by subsoiler or v-ripper	ha

The activities reported in **Table 56** have been deleted and replaced with new state-specific geographies in the United States (US) reported in **Table 55**. This has allowed for greater granularity of data and increased regionalization of the inventory for the specified crops. The markets have been updated accordingly.

Table 56. Activities replaced in the database with new granular datasets in v3.10, related to United States production.

Activity Name	Geography	Time Period	Product Name	Unit
maize grain production	US	2004-2006	maize grain	kg
potato production	US	2001-2006	potato	kg
soybean production	US	2004-2007	soybean	kg
sweet corn production	US	2006-2012	sweet corn	kg

7.4 Flax fibre production in Europe (RER)

The update was performed in collaboration with Alliance for European Flax Linen & Hemp and resulted in the addition of new products in Europe. The new agricultural products are three, namely: flax straw, dew-retted; and both long and short flax fibres obtained as co-products from the scutching operation. The new products are available for Europe and represent the average for France and Belgium-Netherlands. All new products are reported in detail in **Table 57.**

Table 57: New activities added for v3.10, related to flax fibre production in Europe.

Activity Name	Geography	Time Period	Product Name	Unit
fibre production, flax, scutching	RER	2014-2018	fibre, flax, long, scutched	kg
fibre production, flax, scutching	RER	2014-2018	fibre, flax, short, scutched	kg
flax straw production, dew-retted	RER	2013-2018	flax straw, dew-retted	kg

7.5 Corrections in the sector

The following datasets are updated based on corrections implemented from v3.9.1 to v3.10. **Table 58** provides a clear description of all the activities updated and the type of correction developed. The major modifications are the following:

- In the Brazilian datasets of ”soybean production”, “maize grain production, first crop” and “maize grain production, second crop” the amount of “Water, unspecified natural origin” and “Water, to air” are adjusted. This change took place because the original water values were provided in kg, not in m3. Therefore. they were not in accordance with the flow unit. So, they were divided by a factor of 1000 to represent m3.

- In the Canadian datasets of “protein pea”, and “lentil”, the values for ammonium sulfate; diammonium phosphate; monoammonium phosphate; potassium chloride; potassium sulfate; urea ammonium nitrate mix, and urea were updated from the amount of nutrient (N, P, K) in the fertilizer, to the amount of fertilizer product. The correction was to divide each fertilizer flow by the relevant nutrient content. Also, the comments have been updated for each flow accordingly. This does not affect the emissions modelling since these were all calculated based on the relevant nutrient contents and the only issue was the difference in background modelling for fertilizers. Also, the amount of seeding rate has been updated based on data provider revision.
- In the Indian datasets of “rice basmati production” and “rice non-basmati production” the mount of irrigation was corrected to 0.826 m3, according to Table 5, p. 22 of https://www.waterfootprint.org/resources/Report40-WaterFootprintRice.pdf. The elementary exchanges "Water" to Environment were adjusted accordingly
- In the Global datasets of “soybean production, GLO” the amount of greenhouse gases due to land use change (LUC) has been revised. For global datasets the emissions from LUC are given by the elementary exchange “Carbon dioxide, from soil or biomass stock”. Consequently, the amount of this exchange was corrected from around 4.58 to 2.01 kgCO2 for v3.10.
- In the South Africa (ZA) and Global (GLO) datasets of “maize grain production, rainfed” in the amount of the exchanges ‘Occupation, annual crop, irrigated’ and ‘Occupation, annual crop, irrigated’, respectively, there was a mistake in the unit conversion from ha to m2. Therefore, in v3.10 the amounts have been corrected and multiplied by a factor of 10^4.
- Until v3.9.1, the Global datasets of “rape seed production, GLO”, was calculated as a weighted of the geographies France (FR), Germany (DE) and the United Sates (US). For v3.10 the dataset has been recalculated also including the geographies Canada-Québec (CA-QC) and Canada without Québec. The weighted average is calculated according to the production volume of the reference product for each country. Therefore, the production volume for all the geographies has been updated for the year 2021. Additionally, the impact of land use change (LUC) was lacking for FR, DE and the GLO geographies. Therefore, for FR and DE the exchange ‘land use change, annual crop’ has been added, whereas for GLO the exchange ‘Carbon dioxide, from soil or biomass stock’ has been added, with the respective amounts.
- In the Bangladesh (BD) datasets of “fibre production, jute, retting”, the exchange from technosphere “jute plant, harvested” has been revised. According to the documentation of the dataset and the properties of the exchange, the input should be in green matter, but is given as dry mass. Consequently, the amount of the exchange ‘jute plant, harvested’ has been corrected as green matter by dividing the amount given in dry mass by the dry mass property of this exchange. This way the BD and India (IN) datasets are compatible. Additionally, the amounts of the exchanges ‘Water’ and ‘transport, freight, lorry, unspecified’ of the BD have been adjusted to the new amount of ‘jute plant, harvested’. Furthermore, due to the correction in the BD dataset, the GLO dataset for this activity has been recalculated as the weighted average of the BD and IN datasets, according to their production volumes.
- In the Rest of the World (RoW) datasets of “cotton-seed production”, there was an issue related to diesel consumption per ha based on the field operations

detailed for RoW. Most of the diesel consumption was driven by the specific tillage, ploughing activity that it resulted in almost 7 Ha of ploughing activity. In coherence with the refence the amount of tillage, ploughing has been revised for RoW.

Table 58: Activities corrected for v3.10 in the Agricultural sector.

Activity Name	Geography	Time Period	Product Name	Type of correction
coffee green bean production, arabica, irrigated	BR-MG	2020-2022	coffee, green bean	The water input amount is updated based on information provided by the Brazilian data providers. Water balance is also adjusted
coffee green bean production, arabica, mechanized	BR-MG	2020-2022	coffee, green bean	The water input amount is updated based on information provided by the Brazilian data providers. Water balance is also adjusted
fibre production, jute, retting	BD; GLO	2016-2017	fibre, jute	The amount of the exchange 'jute plant, harvested' has been corrected as green matter by dividing the amount given in dry mass by the dry mass property of this exchange.
lentil production	CA-AB; CA-SK; GLO	2017-2019	lentil	The amount of fertilisers has been updated.
lentil production	CA-AB; CA-SK; GLO	2017-2019	lentil	The amount of seeding rate was updated.
maize grain production	ZA	2006-2013	maize grain	The amounts of exchanges 'Occupation, annual crop, irrigated' and 'Occupation, annual crop, irrigated', have been corrected and multiplied by a factor of 10^4.
maize grain production, first crop	BR-BA; BR-GO; BR-MA; BR-MG; BR-PI; BR-PR; BR-RS	2015-2022	maize grain	The amount of 'water, unspecified natural origin' and 'water, to air' are adjusted. This change took place because the original water values were provided in kg, not in m3. Therefore. They were not in accordance with the flow unit. So, they were divided by a factor of 1000 to represent m3.
maize grain production, rainfed	GLO; ZA	2006-2013	maize grain	The amounts of exchanges 'Occupation, annual crop, irrigated' and 'Occupation, annual crop, irrigated', have been corrected and multiplied by a factor of 10^4.
maize grain production, second crop	BR-GO; BR-MA; BR-MG; BR-MS; BR-MT; BR-PR; BR-SP; BR-TO	2015-2022	maize grain	The amount of 'water, unspecified natural origin' and 'water, to air' are adjusted. This change took place because the original water values were provided in kg, not in m3. Therefore. They were not in

Activity Name	Geography	Time Period	Product Name	Type of correction
				accordance with the flow unit. So, they were divided by a factor of 1000 to represent m3.
protein pea production	CA-AB; CA-MB; CA-SK	2017-2019	protein pea	The amount of fertilisers has been updated.
protein pea production	CA-AB; CA-MB; CA-SK	2017-2019	protein pea	The amount of seeding rate was updated.
rape seed production	DE; FR	2000-2004	rape seed	The production volume for all the geographies has been updated for the year 2021.
rape seed production	GLO	2000-2012	rape seed	The production volume for all the geographies has been updated for the year 2021.
rape seed production	Canada without Quebec	2009-2012	rape seed	The production volume for all the geographies has been updated for the year 2021.
rice production, basmati	GLO; IN	2015-2018	rice, basmati	Corrected amount of irrigation and emissions of water.
rice production, non-basmati	IN	2015-2018	rice, non-basmati	Corrected amount of irrigation and emissions of water.
soybean production	BR-BA; BR-GO; BR-MA; BR-MG; BR-MS; BR-MT; BR-PI; BR-PR; BR-RS; BR-SP; BR-TO	2015-2022	soybean	The amount of 'water, unspecified natural origin' and 'water, to air' are adjusted. This change took place because the original water values were provided in kg, not in m3. Therefore. They were not in accordance with the flow unit. So, they were divided by a factor of 1000 to represent m3.
soybean production	GLO	2004-2006	soybean	Amount of greenhouse gases due to land use change (LUC) has been revised
seed-cotton production, conventional	GLO	2016-2016	seed-cotton	The amount of tillage ploughing has been revised

7.6 Land Use Change FLAG Emissions

Agricultural datasets in ecoinvent account for most of the emission sources mentioned in the Forest, Land and Agriculture (FLAG) Guidance (Christa Anderson, 2022). In order to support users which are interested in setting science-based targets for FLAG-related greenhouse gas emissions and removals (Pete, et al., 2016) according to the new, refined pathways in the FLAG, ecoinvent has developed for v3.10 for the Agricultural datasets an Excel file that includes a separate calculation of Land Use Change (LUC)-related FLAG emissions both for the datasets that already have Land LUC declared in the inventories, and LUC values + FLAG emissions for those that don't have LUC amount inventoried. It includes the main agricultural products (i.e. allocatable by-products of agricultural production are NOT included). The Excel file will be accessible by license owners via the "Files" section in ecoquery.

8 Building and construction materials

8.1 Updated cement and clinker datasets for Switzerland

For v3.10, cement and clinker datasets for Switzerland have been updated with data from 2017-2021. Data has been provided by cemsuisse, the Swiss Cement Association, and is based on the national average of all cement producers in Switzerland. This update concerns ‘clinker production’, ‘cement production, Portland’, ‘cement production, CEM II/A’ and ‘cement production, CEM II/B’. For clinker the data in v3.9.1 was from 2005-2009, whereas for the mentioned cement datasets it was 2009-2010.

Until v3.9.1, several different types of cement for Switzerland were present in the database. However, according to cemsuisse, some of these are not produced anymore in Switzerland. These were therefore excluded from the database for v3.10 (cement, CEM III/A; cement, CEM III/C; cement, CEM IV/A; cement, CEM IV/B; cement, CEM V/A; and cement, CEM V/B). Consequently, the ‘cement all types to generic market for cement, unspecified’ yielding the product ‘cement, unspecified’ for Switzerland is calculated with the shares of each type of cement produced in Switzerland for 2021 (cement, Portland; cement, CEM II/A; cement, CEM II/B; and cement, CEM III/B). The ‘cement, ZN/D, new alternative constituents 36-50%, in conformity with SIA 2049’ has not been included in the ‘cement, unspecified’ due to confidentiality reasons for the production volume of this cement.

In **Table 59** the updated and deleted datasets for Switzerland are illustrated. For the activities ‘cement production, CEM III/B’ and ‘cement, unspecified, import from Europe’ the production volumes are updated for the year 2021, following the other Swiss cement datasets.

Table 59. Cement and clinker datasets for Switzerland for v3.10 of the database. “N” stands for “New Activity”, “U” stands for “Updated Activity”, "*" is used to indicate activities where only the production volume has been updated, “D” stands for “Deleted Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
clinker production	CH	2017-2021	clinker	kg	U
cement production, Portland	CH	2017-2021	cement, Portland	kg	U
cement production, CEM II/A	CH	2017-2021	cement, CEM II/A	kg	U
cement production, CEM II/B	CH	2017-2021	cement, CEM II/B	kg	U
cement all types to generic market for cement, unspecified	CH	2021-2021	cement, unspecified	kg	U
cement, unspecified, import from Europe	CH	2021-2021	cement, unspecified	kg	U*
cement production, CEM III/B	CH	2021-2021	cement, CEM II/B	kg	U*
cement production, CEM III/A	CH	2005-2009	cement, CEM III/A	kg	D
cement production, CEM III/C	CH	2005-2009	cement, CEM III/C	kg	D
cement production, CEM IV/A	CH	2005-2009	cement, CEM IV/A	kg	D

cement production, CEM IV/B	CH	2005-2009	cement, CEM IV/B	kg	D
cement production, CEM V/A	CH	2005-2009	cement, CEM V/A	kg	D
cement production, CEM V/B	CH	2005-2009	cement, CEM V/B	kg	D
market for cement, CEM III/A	CH	2005-2009	cement, CEM III/A	kg	D
market for cement, CEM III/C	CH	2005-2009	cement, CEM III/C	kg	D
market for cement, CEM IV/A	CH	2005-2009	cement, CEM IV/A	kg	D
market for cement, CEM IV/B	CH	2005-2009	cement, CEM IV/B	kg	D
market for cement, CEM V/A	CH	2005-2009	cement, CEM V/A	kg	D
market for cement, CEM V/B	CH	2005-2009	cement, CEM V/B	kg	D

8.2 New cement and clinker datasets for Tunisia

In v3.10 a new geography is added to the African continent for the construction sector; Tunisia. Data was provided by the University of Tunis El Manar and stem from primary data collection and measurements done in Tunisia for 2019.

Clinker, the primary material for the production of cement, is added for Tunisia. Additionally, three types of cement are introduced in v3.10, namely ‘cement, Portland’, ‘cement, CEM II/A-L’ and ‘cement, Portland SR3’, the latter being a new product to the database. The naming convention follows the Tunisian standard NT 47.01 (2017). Additionally, the markets for the 4 products are added. The list of datasets added in v3.10 can be seen in **Table 60**.

Table 60. New cement and clinker datasets for Tunisia for v3.10 of the database. “N” stands for “New Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
clinker production	TN	2019-2019	clinker	kg	N
cement production, Portland	TN	2019-2019	cement, Portland	kg	N
cement production, CEM II/A-L	TN	2019-2019	cement, CEM II/A-L	kg	N
cement production, Portland SR3	TN	2019-2019	cement, Portland SR3	kg	N
cement all types to generic market for cement, unspecified	TN	2019-2019	cement, unspecified	kg	N
market for clinker	TN	2019-2019	clinker	kg	N
market for cement, Portland	TN	2019-2019	cement, Portland	kg	N
market for cement, CEM II/A-L	TN	2019-2019	cement, CEM II/A-L	kg	N
market for cement, Portland SR3	TN	2019-2019	cement, Portland SR3	kg	N
market for cement, unspecified	TN	2019-2019	cement, unspecified	kg	N

8.3 New construction material datasets for Ecuador

For v3.10, new construction materials for Ecuador, including bamboo, have been added to the database. The data has been provided by EMPA, with cooperation with the Inclusive Circular Economy and Sustainable Development Research Group of the University of Cuenca (ECI) in the frame of the CEELA (Strengthening capacities for energy efficiency in buildings in Latin America) project with the support of the Swiss Agency for Development and Cooperation (SDC). The new datasets for Ecuador can be seen in **Table 61**.

A brand-new product has been added to the database, namely ‘adobe brick’. The activity ‘adobe brick production’ is added for Ecuador (EC) and the Global (GLO) geographies. In addition, two different production technologies have been added for the product ‘clay brick’ in Ecuador, specifically ‘clay brick production, extruded’ and ‘clay brick production, moulded’ for EC. This activity was already in the database for RER and GLO. Consequently, after reviewing the existing activities, the RER and GLO activities have been renamed to ‘clay brick production, extruded’ in v3.10. For the product ‘clay roof tile’, two processes exist for EC, namely ‘clay roof tile production’ and ‘clay roof tile production, glazed’. The conventional production process was already part of the database with the name ‘roof tile production’. Since clay is used as the raw material to produce the roof tile, both the transforming and the market activities have been renamed for the RER and GLO geographies in v3.10. The renaming of the activities mentioned can be seen in **Table 1**.

During the production process of clay bricks and clay roof tiles in Ecuador, some get damaged in the firing process in the oven. These are modelled by the ‘damaged clay material’ exchange in ‘clay brick production, extruded’, clay brick production, moulded’ and ‘clay roof tile production’. For ‘clay roof tile production, glazed’ another exchange is modelled, namely ‘clay roof tile production, glazed’, since for the glazed version of the clay roof tile some chemicals are used in the production process. Both damaged products are modelled as open dump.

Additionally, fundamental construction materials, such as clinker, have been added for Ecuador. This is then used as an input for ‘cement production, type general use’, which in turn is used to produce ‘concrete block’. All these for EC. Concrete block was already existing in the database for Brazil (BR), Germany (DE) and global (GLO), where GLO was a copy of DE. The DE dataset has a different structure than BR and EC, since it considers the ready-mix concrete as input, instead of cement and other raw materials to produce the concrete, and then produce concrete block. Therefore, the GLO was recalculated as a weighted average of BR and EC, which have a similar production process.

Table 61. New datasets for Ecuador in the construction sector for v3.10. N” stands for “New Activity”, “U” stands for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
adobe brick production	EC; GLO	2022-2023	adobe brick	kg	N
clay brick production, extruded	EC	2022-2023	clay brick	kg	N
clay brick production, moulded	EC	2022-2023	clay brick	kg	N

clay roof tile production	EC	2022-2023	clay roof tile	kg	N
clay roof tile production, glazed	EC	2022-2023	clay roof tile	kg	N
treatment of damaged clay material, open dump	EC	2022-2022	damaged clay material	kg	N
treatment of damaged clay roof tile, glazed, open dump	EC	2022-2022	damaged clay roof tile, glazed	kg	N
market for damaged clay material	EC	2010-2022	damaged clay material	kg	N
market for damaged clay roof tile, glazed	EC	2010-2022	damaged clay roof tile, glazed	kg	N
clinker production	EC	2019-2023	clinker production	kg	N
cement production, type general use	EC	2019-2023	cement, type general use	kg	N
cement, all types to generic market for cement, unspecified	EC	2019-2023	cement, unspecified	kg	N
concrete block production	EC	2022-2023	concrete block	kg	N
market for adobe brick	EC; GLO	2022-2023	adobe brick	kg	N
market for clay brick	EC	2022-2023	clay brick	kg	N
market for clay roof tile	EC	2022-2023	clay roof tile	kg	N
market for clinker	EC	2019-2023	clinker	kg	N
market for concrete block	EC	2022-2023	concrete block	kg	N
concrete block production	GLO	2012-2023	concrete block	kg	U

8.4 Other updates

8.4.1 Concrete exchange in Swiss datasets

In v3.9, the cement and concrete sector were restructured based on specific nomenclature rules. A generic type of concrete, ‘concrete, normal strength’ was created for Switzerland. After implementing the restructuring and renaming in v3.9, it became clear that some infrastructure datasets for Switzerland were supplied with the wrong type of concrete. This was corrected in v3.10. The concrete exchanges were modified for the datasets in **Table 62**.

Table 62. Activity name, geography, and exchange name for activities in v3.9 and the corresponding exchange name for v3.10.

Activity Name	Geography	Exchange Name v3.9	Exchange Name v3.10	Time Period
anaerobic digestion plant construction, agricultural	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2005
anaerobic digestion plant construction,	CH	unreinforced concrete, 15MPa	concrete, normal strength	2004 - 2006

agriculture, with methane recovery					
anaerobic digestion plant construction, for biowaste	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2000
anaerobic digestion plant construction, for sewage sludge	CH		unreinforced concrete, 15MPa	concrete, normal strength	2002 - 2002
building construction, hall, steel construction	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
dried roughage store construction, air dried, solar	CH		unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
dried roughage store construction, cold-air dried, conventional	CH		unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
dried roughage store construction, non ventilated	CH		unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
dung slab construction	CH		unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
electricity production, nuclear, boiling water reactor	CH		unreinforced concrete, 15MPa	concrete, normal strength	1990 - 2015
electricity production, nuclear, pressure water reactor	CH		unreinforced concrete, 15MPa	concrete, normal strength	1990 - 2015
furnace production, logs, 30kW	CH		unreinforced concrete, 15MPa	concrete, normal strength	2010 - 2011
furnace production, logs, average storage area, 100kW	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, logs, average storage area, 30kW	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, logs, average storage area, 6kW	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, logs, hardwood storage area, 100kW	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, logs, hardwood storage area, 30kW	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, logs, hardwood storage area, 6kW	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, logs, softwood storage area, 100kW	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, logs, softwood storage area, 30kW	CH		unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001

furnace production, logs, softwood storage area, 6kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, pellet, 15kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, pellet, 50kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, pellets, 25kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2010 - 2011
furnace production, pellets, with silo, 300kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2010 - 2011
furnace production, wood chips, average storage area, 1000kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, wood chips, average storage area, 300kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, wood chips, average storage area, 50kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, wood chips, hardwood storage area, 1000kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, wood chips, hardwood storage area, 300kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, wood chips, hardwood storage area, 50kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, wood chips, softwood storage area, 1000kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, wood chips, softwood storage area, 300kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, wood chips, softwood storage area, 50kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
furnace production, wood chips, with silo, 1000kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2010 - 2011
furnace production, wood chips, with silo, 300kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2010 - 2011
furnace production, wood chips, with silo, 5000kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2010 - 2011

furnace production, wood chips, with silo, 50kW	CH	unreinforced concrete, 15MPa	concrete, normal strength	2010 - 2011
garage construction, wood, non-insulated, fire-protected	CH	unreinforced concrete, 15MPa	concrete, normal strength	2009 - 2012
heat and power co-generation unit construction, 6400kW thermal, building	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
heat and power co-generation unit construction, 6400kW thermal, common components for heat+electricity	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
heat and power co-generation unit construction, organic Rankine cycle, 1400kW thermal, building	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
heat and power co-generation unit construction, organic Rankine cycle, 1400kW thermal, common components, heat+el	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2001
housing system construction, cattle, loose	CH	unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
housing system construction, cattle, tied	CH	unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
housing system construction, pig, electricity from renewable energy products	CH	unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
housing system construction, pig, fully-slatted floor	CH	unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
liquid manure storage and processing facility construction	CH	unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
milking parlour construction	CH	unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
natural gas service station construction	CH	unreinforced concrete, 15MPa	concrete, normal strength	2001 - 2001
nuclear power plant construction, boiling water reactor 1000MW	CH	unreinforced concrete, 15MPa	concrete, normal strength	1984 - 2002

nuclear power plant construction, pressure water reactor, 1000MW	CH	unreinforced concrete, 15MPa	concrete, normal strength	1979 - 2002
nuclear spent fuel conditioning facility construction	CH	unreinforced concrete, 15MPa	concrete, normal strength	2002 - 2002
nuclear waste storage construction, final repository for high level radioactive waste	CH	unreinforced concrete, 15MPa	concrete, normal strength	1985 - 2002
nuclear waste storage construction, final repository for low level radioactive waste	CH	unreinforced concrete, 15MPa	concrete, normal strength	1985 - 2002
nuclear waste storage construction, interim, for high level radioactive waste before final repository	CH	unreinforced concrete, 15MPa	concrete, normal strength	1992 - 1998
nuclear waste storage construction, interim, for low level radioactive waste before final repository	CH	unreinforced concrete, 15MPa	concrete, normal strength	1992 - 1998
oil storage production, 3000l	CH	unreinforced concrete, 15MPa	concrete, normal strength	1993 - 1993
pipeline construction, natural gas, high pressure distribution network	CH	unreinforced concrete, 15MPa	concrete, normal strength	2012 - 2012
pipeline construction, natural gas, low pressure distribution network	CH	unreinforced concrete, 15MPa	concrete, normal strength	2012 - 2012
pump station construction	CH	unreinforced concrete, 15MPa	concrete, normal strength	1993 - 1998
shed construction	CH	unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
shed construction, large, wood, non-insulated, fire-unprotected	CH	unreinforced concrete, 15MPa	concrete, normal strength	2009 - 2012
synthetic gas factory construction	CH	unreinforced concrete, 15MPa	concrete, normal strength	2004 - 2006
tower silo production, plastic	CH	unreinforced concrete, 15MPa	concrete, normal strength	1994 - 2002
treatment of high level radioactive waste for final repository	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2002

treatment of low level radioactive waste for final repository	CH	unreinforced concrete, 15MPa	concrete, normal strength	1985 - 2002
waste preparation facility construction	CH	unreinforced concrete, 15MPa	concrete, normal strength	2000 - 2014
water storage construction	CH	unreinforced concrete, 15MPa	concrete, normal strength	1993 - 1998
water works construction, capacity 1.1E10l/year, conventional treatment	CH	unreinforced concrete, 15MPa	concrete, normal strength	2009 - 2009
water works construction, capacity 1.1E10l/year, direct filtration treatment	CH	unreinforced concrete, 15MPa	concrete, normal strength	2009 - 2009
chimney production	CH	concrete, 25MPa	concrete, 37MPa	1993 - 1993
railway track construction	CH	concrete, 25MPa	concrete, 37MPa	1990 - 2000
wastewater treatment facility construction, capacity 1.6E8l/year	CH	concrete, 25MPa	concrete, 37MPa	1996 - 2000
wastewater treatment facility construction, capacity 5E9l/year	CH	concrete, 25MPa	concrete, 37MPa	1996 - 2000

8.4.2 Ground granulated blast furnace slag production, GLO

Until v3.9.1, ground granulated blast furnace slag (GGBFS) for the Global (GLO) geography was a copy of the US dataset. For v3.10, the GLO has been updated as a weighted average of all regional datasets with same activity name, namely US, IN and ZA. For this, the production volume of all datasets, including GLO, has been updated. The updated datasets can be found in **Table 63**.

8.4.3 Cement production, Portland, GLO

With the addition of the activity ‘cement production, Portland’ for TN and the update of the same activity for CH, the GLO dataset has been updated as a weighted average of all regional datasets with same activity name, according to their production volumes. Since the production volumes for all cement production activities have been updated for v3.9.1, no update was done for the production volume in v3.10. The updated dataset can be found in **Table 63**. The clinker production activity for the Global geography was not updated with the new additions (EC, TN) and update (CH) since the three geographies make up only 3% of the total production volume when considering all geographies.

8.4.4 Cement production, CEM II/A-L, ZA

For the dataset ‘cement production, CEM II/A-L’ for South Africa (ZA) an exchange ‘scrap steel’ has been added to account for the waste produced due to the input of ‘steel, low alloyed’. This was done since the TN dataset for the same activity has been added for v3.10. The updated dataset can be found in **Table 63**.

8.4.5 Clinker production, BR

The activity ‘clinker production’ for all geographies, except Brazil (BR) and Switzerland (CH) has an exchange From Technosphere ‘cement factory’ to account for infrastructure. This has now been added in v3.10 also for the BR dataset, with the same amount as given in the other geographies. The updated dataset can be found in **Table 63**. For the CH dataset the exchange has not been added since the CH dataset has been updated for 3.10 with primary data. According to the data provider of the clinker production activity for Switzerland, clinker and cement are produced on one site. Therefore, the infrastructure on that site has been split between clinker and cement production activities, where for clinker the exchange ‘industrial machine, heavy, unspecified’ is used to model the kiln, and in the cement activities the exchange ‘cement factory’ is used to model the infrastructure without the clinker production.

Table 63. Quantitative corrections done in the construction sector for v3.10. “U” stands for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
ground granulated blast furnace slag production	US	2001-2002	blast furnace slag	kg	U
ground granulated blast furnace slag production	GLO	2001-2017	blast furnace slag	kg	U
ground granulated blast furnace slag production	IN	2014-2017	blast furnace slag	kg	U
ground granulated blast furnace slag production	ZA	2017-2017	blast furnace slag	kg	U
cement production, Portland	GLO	2005-2022	cement, Portland	kg	U
cement production, CEM II/A-L	ZA	2017-2022	cement, CEM II/A-L	kg	U
clinker production	BR	2016-2016	clinker	kg	U

9 Wood and Forestry

9.1 New bamboo datasets for Ecuador

Some of the existing activities in the database for bamboo production are now regionalized for Ecuador, illustrated in **Table 64**. The data, including several construction materials, has been provided by EMPA, with cooperation with the Inclusive Circular Economy and Sustainable Development Research Group of the University of Cuenca (ECI) in the frame of the CEELA (Strengthening capacities for energy efficiency in buildings in Latin America) project with the support of the Swiss Agency for Development and Cooperation (SDC).

Due to the addition of in v3.10 of ‘bamboo forestry, sustainable forest management’, ‘bamboo pole production’ and ‘flattened bamboo production’ for Ecuador, the production volume of the same activities has been updated for the other existing geographies, namely Brazil (BR), Colombia (CO), China (CN), Philippines (PH) and global (GLO). For the GLO geography the activities have been recalculated as a weighted average of all existing geographies with same activity name, including EC. In addition, for the activity ‘woven bamboo mat production’ the production volume for all existing geographies has been updated in v3.10, and the water properties for the exchange ‘waste bamboo residues’ have been adjusted. The new and updated datasets are listed in **Table 64**.

Table 64. New bamboo datasets for Ecuador and updated bamboo datasets for other geographies in v3.10. “N” stands for “New Activity”, “U” stands for “Updated Activity”.

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
bamboo forestry, sustainable forest management	EC	2010-2028	bamboo culm	kg	N
bamboo pole production	EC	2010-2028	bamboo pole	kg	N
flattened bamboo production	EC	2010-2028	flattened bamboo	kg	N
market for bamboo culm	EC	2010-2023	bamboo culm	kg	N
market for bamboo pole	EC	2010-2023	bamboo pole	kg	N
market for flattened bamboo	EC	2010-2023	flattened bamboo	kg	N
bamboo forestry, sustainable forest management	BR; CN; CO; PH	2010-2020	bamboo culm	kg	U
bamboo forestry, sustainable forest management	GLO	2010-2020	bamboo culm	kg	U
bamboo pole production	BR; CO; PH	2010-2020	bamboo pole	kg	U
bamboo pole production	CN; GLO	2010-2020	bamboo pole	kg	U
flattened bamboo production	BR; CN; CO; PH	2010-2020	flattened bamboo	kg	U
flattened bamboo production	GLO	2010-2020	flattened bamboo	kg	U
woven bamboo mat production	BR; CN; CO; GLO; PH	2010-2020	woven bamboo mat	kg	U

9.2 Updated transport inputs in markets

Transport inputs were added or updated in some markets in the Pulp & Paper and Forestry & Wood sectors. The markets that had either wrong amounts of transportation or were missing it entirely. The updated markets are shown in **Table 65**.

Table 65. Markets that were updated. If several geographies of the same market with the same time period exist, all of them are listed in the "Geography" column. "U" stands for updated transportation and "A" for added transportation.

Activity Name	Geography	Time Period	Product Name	Unit	Change
market for corrugated board box	CA-QC	2008-2008	corrugated board box	kg	U
market for corrugated board box	RER	2009-2015	corrugated board box	kg	U
market for corrugated board box	US	2014-2022	corrugated board box	kg	U
market for sawnwood, hardwood, dried (u=10%), planed	GLO; RER	2011-2011	sawnwood, hardwood, dried (u=10%), planed	m3	A
market for sawnwood, hardwood, dried (u=20%), planed	GLO; RER	2011-2011	sawnwood, hardwood, dried (u=20%), planed	m3	A
market for sawnwood, hardwood, raw, dried (u=10%)	GLO; RER	2011-2011	sawnwood, hardwood, raw, dried (u=10%)	m3	A
market for sawnwood, hardwood, raw, dried (u=20%)	GLO; RER	2011-2011	sawnwood, hardwood, raw, dried (u=20%)	m3	A
market for sawnwood, softwood, dried (u=10%), planed	GLO; RER	2011-2011	sawnwood, softwood, dried (u=10%), planed	m3	A
market for sawnwood, softwood, dried (u=20%), planed	GLO; RER	2011-2011	sawnwood, softwood, dried (u=20%), planed	m3	A
market for sawnwood, softwood, raw, dried (u=10%)	GLO; RER	2011-2011	sawnwood, softwood, raw, dried (u=10%)	m3	A
market for sawnwood, softwood, raw, dried (u=20%)	GLO; RER	2011-2011	sawnwood, softwood, raw, dried (u=20%)	m3	A

10 Pulp and paper

10.1 Containerboard

Data for European containerboard and corrugated board box production were updated based on the 2021 European Database for Corrugated Board Life Cycle Studies issued by the European Federation of Corrugated Board Manufacturers (FEFCO) and Cepi ContainerBoard (FEFCO, 2021). The update was performed in collaboration with RISE Research Institutes of Sweden.

Updated datasets related to containerboard production are shown in **Table 66**

Table 66. Updated activities related to containerboard production. If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column. The unit of all reference products is kg.

Activity Name	Geography	Time Period	Product Name
containerboard production, fluting medium, recycled	GLO; RER	2021-2023	containerboard, fluting medium
containerboard production, fluting medium, semichemical	GLO; RER	2017-2021	containerboard, fluting medium
containerboard production, linerboard, kraftliner	CA-QC; GLO; RER	2021-2023	containerboard, linerboard
containerboard production, linerboard, testliner	GLO	2007-2023	containerboard, linerboard
containerboard production, linerboard, testliner	RER	2021-2023	containerboard, linerboard
corrugated board box production	GLO	2008-2023	corrugated board box
corrugated board box production	RER	2021-2023	corrugated board box
market for containerboard, linerboard	RER	2021-2023	containerboard, linerboard
market for containerboard, fluting medium	RER	2021-2023	containerboard, fluting medium

11 Metals

This update expands the data coverage of the Metals sector with new and updated data. Specifically, ecoinvent v3.10 introduces data on thermal spraying (Atmospheric Plasma Spray (APS), High Velocity OxyFuel (HVOF), and Cold Spray (CS)). Prices of rare earth oxides are also updated.

11.1 Rare earth elements

The prices of Rare Earth Oxides (REO) have been updated to improve the quality and the consistency of the allocation of the impacts. This harmonization is based on a unique source for the prices of all REO, which ensures a more reliable representation of the ratio between the prices of the different REO. The selected source of data is the Institut für Seltene Erden und Metallen, which aggregates market data about the price of all the REO in a consistent manner. Price points are aggregated to obtain long-term averages.

This update led to changes in the impacts of several REO, which were previously relying on estimated prices. This is due to the changes in ratios of the prices, which changes how much impact is allocated to each of the REO produced, since many of them are produced by the same activity.

11.2 Thermal spraying

Data for thermal spray processing were added to the database (**Table 67**) based on data provided by the Centro de Proyección Térmica of the Universitat de Barcelona, which is specialized since 1994 within the field of Surface Engineering. The collaboration enabled the integration in the database of three datasets that model the application of a surface coating, and one dataset dedicated to the preparation of the workpieces.

Table 67. New datasets for thermal spraying. The unit of all reference products is m2. In column „3.10“ „N“ stands for „New activity“.

Activity Name	Geography	Time Period	Product Name	3.10
abrasive blasting, alumina, carbon steel substrate	GLO	2022-2022	abrasive blasting, alumina, carbon steel substrate	N
thermal spraying, atmospheric plasma spray, tungsten carbide-cobalt, on carbon steel substrate	GLO	2022-2022	thermal spraying, atmospheric plasma spray, tungsten carbide-cobalt, on carbon steel substrate	N
thermal spraying, cold spray, tungsten carbide-cobalt, on carbon steel substrate	GLO	2022-2022	thermal spraying, cold spray, tungsten carbide-cobalt, on carbon steel substrate	N
thermal spraying, high velocity oxyfuel, tungsten carbide-cobalt, on carbon steel substrate	GLO	2022-2022	thermal spraying, high velocity oxyfuel, tungsten carbide-	N

			cobalt, on carbon steel substrate	
market for abrasive blasting, alumina, carbon steel substrate	GLO	2022-2022	abrasive blasting, alumina, carbon steel substrate	N
market for thermal spraying, atmospheric plasma spray, tungsten carbide-cobalt, on carbon steel substrate	GLO	2022-2022	thermal spraying, atmospheric plasma spray, tungsten carbide-cobalt, on carbon steel substrate	N
market for thermal spraying, cold spray, tungsten carbide-cobalt, on carbon steel substrate	GLO	2022-2022	thermal spraying, cold spray, tungsten carbide-cobalt, on carbon steel substrate	N
market for thermal spraying, high velocity oxyfuel, tungsten carbide-cobalt, on carbon steel substrate	GLO	2022-2022	thermal spraying, high velocity oxyfuel, tungsten carbide-cobalt, on carbon steel substrate	N

11.3 Machining and casting, byproducts update

In order to increase clarity and consistency, an update of the machining and casting processes was performed; the complete list of the affected datasets is reported in **Table 68**. These datasets were first stored in ecoinvent version 2, where the recycled byproducts were not reported. With the current modelling of ecoinvent version 3, this approach was not valid anymore and, consequently, the byproducts were added. The exchanges added refer to the material being removed. These additions enhance the mass balance of the datasets.

Table 68. Updated activities related to machining processes. If several geographies of the same activity with the same time period exist, all of them are listed in the „Geography“ column. The unit of all reference products is kg. In the column „3.10“ „U“ stands for „Updated activity“.

Activity Name	Geography	Time Period	Product Name	3.10
aluminium drilling, computer numerical controlled	GLO; RER	2006-2007	aluminium removed by drilling, computer numerical controlled	U
aluminium drilling, conventional	GLO; RER	2006-2007	aluminium removed by drilling, conventional	U
aluminium milling, average	GLO; RER	2006-2007	aluminium removed by milling, average	U
aluminium milling, dressing	GLO; RER	2006-2007	aluminium removed by milling, dressing	U
aluminium milling, large parts	GLO; RER	2006-2007	aluminium removed by milling, large parts	U
aluminium milling, small parts	GLO; RER	2006-2007	aluminium removed by milling, small parts	U
aluminium turning, average, computer numerical controlled	GLO; RER	2006-2007	aluminium removed by turning, average, computer numerical controlled	U

aluminium turning, average, conventional	GLO; RER	2006-2007	aluminium removed by turning, average, conventional	U
aluminium turning, primarily dressing, computer numerical controlled	GLO; RER	2006-2007	aluminium removed by turning, primarily dressing, computer numerical controlled	U
aluminium turning, primarily dressing, conventional	GLO; RER	2006-2007	aluminium removed by turning, primarily dressing, conventional	U
aluminium turning, primarily roughing, computer numerical controlled	GLO; RER	2006-2007	aluminium removed by turning, primarily roughing, computer numerical controlled	U
aluminium turning, primarily roughing, conventional	GLO; RER	2006-2007	aluminium removed by turning, primarily roughing, conventional	U
cast iron drilling, computer numerical controlled	GLO; RER	2006-2007	cast iron removed by drilling, computer numerical controlled	U
cast iron drilling, conventional	GLO; RER	2006-2007	cast iron removed by drilling, conventional	U
cast iron milling, average	GLO; RER	2006-2007	cast iron removed by milling, average	U
cast iron milling, dressing	GLO; RER	2006-2007	cast iron removed by milling, dressing	U
cast iron milling, large parts	GLO; RER	2006-2007	cast iron removed by milling, large parts	U
cast iron milling, small parts	GLO; RER	2006-2007	cast iron removed by milling, small parts	U
cast iron turning, average, computer numerical controlled	GLO; RER	2006-2007	cast iron removed by turning, average, computer numerical controlled	U
cast iron turning, average, conventional	GLO; RER	2006-2007	cast iron removed by turning, average, conventional	U
cast iron turning, primarily dressing, computer numerical controlled	GLO; RER	2006-2007	cast iron removed by turning, primarily dressing, computer numerical controlled	U
cast iron turning, primarily dressing, conventional	GLO; RER	2006-2007	cast iron removed by turning, primarily dressing, conventional	U
cast iron turning, primarily roughing, computer numerical controlled	GLO; RER	2006-2007	cast iron removed by turning, primarily roughing, computer numerical controlled	U
cast iron turning, primarily roughing, conventional	GLO; RER	2006-2007	cast iron removed by turning, primarily roughing, conventional	U
casting, brass	GLO	1996-2003	casting, brass	U
casting, bronze	GLO	1996-2003	casting, bronze	U
chromium steel drilling, computer numerical controlled	GLO; RER	2006-2007	chromium steel removed by drilling, computer numerical controlled	U

chromium steel drilling, conventional	GLO; RER	2006-2007	chromium steel removed by drilling, conventional	U
chromium steel milling, average	GLO; RER	2006-2007	chromium steel removed by milling, average	U
chromium steel milling, dressing	GLO; RER	2006-2007	chromium steel removed by milling, dressing	U
chromium steel milling, large parts	GLO; RER	2006-2007	chromium steel removed by milling, large parts	U
chromium steel milling, small parts	GLO; RER	2006-2007	chromium steel removed by milling, small parts	U
chromium steel turning, average, computer numerical controlled	GLO; RER	2006-2007	chromium steel removed by turning, average, computer numerical controlled	U
chromium steel turning, average, conventional	GLO; RER	2006-2007	chromium steel removed by turning, average, conventional	U
chromium steel turning, primarily dressing, computer numerical controlled	GLO; RER	2006-2007	chromium steel removed by turning, primarily dressing, computer numerical controlled	U
chromium steel turning, primarily dressing, conventional	GLO; RER	2006-2007	chromium steel removed by turning, primarily dressing, conventional	U
chromium steel turning, primarily roughing, computer numerical controlled	GLO; RER	2006-2007	chromium steel removed by turning, primarily roughing, computer numerical controlled	U
chromium steel turning, primarily roughing, conventional	GLO; RER	2006-2007	chromium steel removed by turning, primarily roughing, conventional	U
steel drilling, computer numerical controlled	GLO; RER	2006-2007	steel removed by drilling, computer numerical controlled	U
steel drilling, conventional	GLO; RER	2006-2007	steel removed by drilling, conventional	U
steel milling, average	GLO; RER	2006-2007	steel removed by milling, average	U
steel milling, dressing	GLO; RER	2006-2007	steel removed by milling, dressing	U
steel milling, large parts	GLO; RER	2006-2007	steel removed by milling, large parts	U
steel milling, small parts	GLO; RER	2006-2007	steel removed by milling, small parts	U
steel turning, average, computer numerical controlled	GLO; RER	2006-2007	steel removed by turning, average, computer numerical controlled	U

steel turning, average, conventional	GLO; RER	2006-2007	steel removed by turning, average, conventional	U
steel turning, primarily dressing, computer numerical controlled	GLO; RER	2006-2007	steel removed by turning, primarily dressing, computer numerical controlled	U
steel turning, primarily dressing, conventional	GLO; RER	2006-2007	steel removed by turning, primarily dressing, conventional	U
steel turning, primarily roughing, computer numerical controlled	GLO; RER	2006-2007	steel removed by turning, primarily roughing, computer numerical controlled	U
steel turning, primarily roughing, conventional	GLO; RER	2006-2007	steel removed by turning, primarily roughing, conventional	U

11.4 Copper supply chain: balancing of elements

Inventories for the main copper supply chain were balanced for elements as described in Turner & Hischier (2020). However, version 3.9.1 featured data gaps and minor inaccuracies that were introduced when importing these material flow analyses to the stored datasets. For version 3.10, datasets (

Table 69) were adjusted for what concerns exchange amounts and properties, while maintaining important changes already implemented for version 3.9.1. This effort was made to obtain datasets that build fully elementally-balanced supply chains.

In the mining stage (“copper mine operation and beneficiation, sulfide ore”; AU, CA, CL, CN, ID, KZ, RU, US, ZM), the amount of Tellurium as input was set to the global value for the regional datasets, since the regional values were wrong. Furthermore, balancing needed some adjustments of Silver and Selenium inputs. For the Canadian dataset, an adjustment of the input of Rhenium was needed. In the smelting stage (“smelting of copper concentrate, sulfide ore”; CL, CN, GLO, IN, JP, RU), the exchange amounts and properties were adjusted to values provided in Turner & Hischier (2020). In the electrorefining stage (“electrorefining of copper, anode, GLO”), the exchange of “copper-rich material” was removed, and the “copper, anode” amount was calculated by the material input from Turner & Hischier (2020) minus the amount of electrolyte. Finally, in the anode slime processing (“processing of anode slime from electrorefining of copper, anode, GLO”), the amount of “copper slag” was adjusted based on Turner & Hischier (2020).

Table 69. Updated datasets related to the copper chain balance. If several geographies of the same activity with the same time period exist, all of them are listed in the „Geography“ column. The unit of all reference products is kg. In the column „3.10“ „U“ stands for „Updated activity“.

Activity Name	Geography	Time Period	Product Name	3.10
copper mine operation and beneficiation, sulfide ore	AU, CA, CL, CN, GLO, ID, KZ, RU, US, ZM	1994-2021	copper concentrate, sulfide ore	U
electrorefining of copper, anode	GLO	1994-2019	copper, cathode	U
processing of anode slime from electrorefining of copper, anode	GLO	2010-2019	copper telluride cement	U
smelting of copper concentrate, sulfide ore	CL, CN, GLO, IN, JP, RU	1994-2019	copper, anode	U

11.5 Zinc mine operation

The dataset “zinc mine operation, GLO” (**Table 70**) was updated to include the extraction from the ground of “germanium” and “indium”.

Table 70 Updated activity related to „zinc mine operation“. The unit of the reference product is kg. In column 3.10, „U“ stands for „Updated Activity“

Activity Name	Geography	Time Period	Product Name	3.10
zinc mine operation	GLO	2012-2017	zinc concentrate	U

12 Various updates

12.1 Correction: wind power plant – moving parts

The exchanges "scrap steel" in the datasets listed in **Table 71** were replaced with "iron scrap" as they are considered to be recycled and "iron scrap" represents iron to be recycled.

Table 71. Corrected datasets for wind power plants. 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
wind power plant construction, 2MW, offshore, moving parts	GLO	1991-2002	wind power plant, 2MW, offshore, moving parts	unit
wind power plant construction, 800kW, moving parts	GLO	1991-2002	wind power plant, 800kW, moving parts	unit

12.2 Correction nuclear power plant construction

The datasets for nuclear power plant construction have been corrected in v3.10, see **Table 72**. The diesel amount has been adjusted to consider both construction and demolition of the plant. Before it was only considering the demolition phase. Additionally, an activity link was added to the exchange 'heat, district or industrial, other than natural gas' to the activity 'heat production, light fuel oil, at industrial furnace 1 MW'. Both diesel and heat amounts have been re-calculated considering the lower heating value (LHV) of the respective fuel.

Table 72. Updated activities of nuclear power plant construction. "U" stands for "Updated Activity".

Activity Name	Geography	Time Period	Product Name	Unit	v3.10
nuclear power plant construction, pressure water reactor, 1000MW	CH; CN; DE; FR; GLO	1979-2002	nuclear power plant, pressure water reactor, 1000MW	unit	U
nuclear power plant construction, pressure water reactor 1000MW	US	1979-2006	nuclear power plant, pressure water reactor, 1000MW	unit	U
nuclear power plant construction, boiling water reactor, 1000MW	CH; CN; DE; FR; GLO	1979-2002	nuclear power plant, boiling water reactor 1000MW	unit	U
nuclear power plant construction, boiling water reactor 1000MW	US	1979-2006	nuclear power plant, boiling water reactor 1000MW	unit	U

12.3 Correction of datasets for heat production, natural gas

In v3.9, heat production datasets were modified to account for the new Lower Heating Value of natural gas. The datasets in **Table 73** were modified again for v3.10, to account for some mistakes in the previous implementation of v3.9.

The datasets in **Table 73** were initially part of ecoinvent v2. The Lower Heating Value (LHV) for natural gas assumed at that version was 36.3MJ/m3 and the input of natural gas was expressed in MJ (Faist Emmenegger M., 2007). Considering that natural gas is expressed in m3 in ecoinvent v3, the amount of natural gas in MJ of v2 has been divided by the updated LHV (36MJ/m3) and by the scaling factor for efficiency (**Table 74**). The efficiency of each system is expressed in relationship to the LHV, hence the efficiency of some systems in **Table 74** can be higher than 1 with respect to the LHV. For example, a natural gas system with 93% efficiency relative to the Higher Heating Value (HHV) has about 102 % efficiency relative to LHV.

Regarding the activity ‘heat production, natural gas, at diffusion absorption heat pump 4kW, future’, 1MJ of heat requires 0.758MJ input of natural gas. The difference to the output of 1 MJ is accounted as ‘energy, geothermal, converted’ (Primas, 2007).

Table 73. 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. The unit of all reference products is MJ.

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

heat production, natural gas, at industrial furnace >100kW	Europe without Switzerland; GLO	2000-2000	heat, district or industrial, natural gas
heat production, natural gas, at industrial furnace low-NOx >100kW	CA-QC	1990-2015	heat, district or industrial, natural gas
heat production, natural gas, at industrial furnace low-NOx >100kW	Europe without Switzerland; GLO	1990-2000	heat, district or industrial, natural gas

Table 74. Calculation of the amount of natural gas input per MJ of heat produced. The efficiency and the MJ input of natural gas are based on (Faist Emmenegger M., 2007). The MJ input of natural gas is calculated as the MJ input required to produce 1MJ of heat, given the efficiency of the second column. The fourth column is calculated by dividing the MJ input by the LHV of natural gas (36MJ/m3).

Activity Name	Efficiency in relationship to LHV (MJheat/MJgasLHV)	MJ input of natural gas (MJgasLHV/MJheat)	m^3 input of natural gas
heat production, natural gas, at boiler atm. low-NOx condensing non-modulating <100kW	1.000	1.000	0.02778
heat production, natural gas, at boiler atmospheric low-NOx non-modulating <100kW	0.920	1.087	0.03019
heat production, natural gas, at boiler atmospheric non-modulating <100kW	0.940	1.064	0.02955
heat production, natural gas, at boiler condensing modulating <100kW	1.020	0.980	0.02723
heat production, natural gas, at boiler condensing modulating >100kW	1.020	0.980	0.02723
heat production, natural gas, at boiler fan burner low-NOx non-modulating <100kW	0.900	1.111	0.03086
heat production, natural gas, at boiler fan burner non-modulating <100kW	0.940	1.064	0.02955
heat production, natural gas, at boiler modulating <100kW	0.960	1.042	0.02894
heat production, natural gas, at boiler modulating >100kW	0.960	1.042	0.02894
heat production, natural gas, at industrial furnace >100kW	0.950	1.053	0.02924
heat production, natural gas, at industrial furnace low-NOx >100kW	0.900	1.111	0.03086
heat production, natural gas, at diffusion absorption heat pump 4kW, future		0.758	0.02106

12.4 Correction: Heat production, untreated waste wood

For all datasets in **Table 75**, the CO2 factors in the mathematical formula used to calculate the amount of biogenic CO2 emissions from untreated waste wood were corrected.

Table 75: Corrected datasets for heat production from untreated waste wood. If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column. The unit of all reference products is kg.

Activity Name	Geography	Time Period	Product Name
heat production, untreated waste wood, at furnace 1000-5000 kW	CH; GLO	2000-2014	waste wood, untreated
heat production, untreated waste wood, at furnace 1000-5000 kW, state-of-the-art 2014	CH; GLO	2014-2014	waste wood, untreated

12.5 Correction: Higher Heating Values (HHV) and Lower Heating Values (LHV)

With the release of v3.9, there was a comprehensive database-wide update of HHV and LHV. However, a few activities were excluded from this update, but this issue has now been rectified.

The properties for the natural gas exchanges have been updated to specify an HHV of 40 MJ/m3 and an LHV of 36 MJ/m3 for the activities listed in **Table 49**.

Table 76. Corrected datasets affected by heating value update. 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
kraft paper production	GLO; RER	2018-2022	kraft paper	kg
liquid packaging board production	GLO; RER	2018-2018	liquid packaging board	kg
corrugated board box production	US	2014-2022	corrugated board box	kg

12.6 Correction: Furnace production

Corrections have been made to the service activities (sheet rolling, steel and drawing of pipe, steel) to align their quantities with the steel exchanges. Additionally, adjustments have been applied to the PV (Production Volume) values of the by-products.

Updated datasets related to furnace production are shown in **Table 77**.

Table 77: Corrected datasets for furnace production. If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column. The unit of all reference products is "unit".

Activity Name	Geography	Time Period	Product Name
furnace production, logs, 6kW	CH; GLO	2010-2011	furnace, logs, 6kW
furnace production, logs, average storage area, 100kW	GLO	2000-2001	furnace, logs, average storage area, 100kW
furnace production, logs, average storage area, 100kW	CH	2000-2001	furnace, logs, average storage area, 100kW
furnace production, logs, average storage area, 30kW	GLO	2000-2001	furnace, logs, average storage area, 30kW
furnace production, logs, average storage area, 30kW	CH	2000-2001	furnace, logs, average storage area, 30kW
furnace production, logs, average storage area, 6kW	GLO	2000-2001	furnace, logs, average storage area, 6kW
furnace production, logs, average storage area, 6kW	CH	2000-2001	furnace, logs, average storage area, 6kW
furnace production, logs, hardwood storage area, 100kW	GLO	2000-2001	furnace, logs, hardwood storage area, 100kW
furnace production, logs, hardwood storage area, 100kW	CH	2000-2001	furnace, logs, hardwood storage area, 100kW
furnace production, logs, hardwood storage area, 30kW	GLO	2000-2001	furnace, logs, hardwood storage area, 30kW
furnace production, logs, hardwood storage area, 30kW	CH	2000-2001	furnace, logs, hardwood storage area, 30kW
furnace production, logs, hardwood storage area, 6kW	CH; GLO	2000-2001	furnace, logs, hardwood storage area, 6kW
furnace production, logs, softwood storage area, 100kW	GLO	2000-2001	furnace, logs, softwood storage area, 100kW
furnace production, logs, softwood storage area, 100kW	CH	2000-2001	furnace, logs, softwood storage area, 100kW
furnace production, logs, softwood storage area, 30kW	GLO	2000-2001	furnace, logs, softwood storage area, 30kW
furnace production, logs, softwood storage area, 30kW	CH	2000-2001	furnace, logs, softwood storage area, 30kW
furnace production, logs, softwood storage area, 6kW	GLO	2000-2001	furnace, logs, softwood storage area, 6kW
furnace production, logs, softwood storage area, 6kW	CH	2000-2001	furnace, logs, softwood storage area, 6kW
furnace production, pellet, 15kW	GLO	2000-2001	furnace, pellet, 15kW
furnace production, pellet, 15kW	CH	2000-2001	furnace, pellet, 15kW
furnace production, pellet, 50kW	GLO	2000-2001	furnace, pellet, 50kW
furnace production, pellet, 50kW	CH	2000-2001	furnace, pellet, 50kW
furnace production, pellets, 25kW	CH; GLO	2010-2011	furnace, pellets, 25kW
furnace production, pellets, 9kW	CH; GLO	2010-2011	furnace, pellets, 9kW
furnace production, pellets, with silo, 300kW	CH; GLO	2010-2011	furnace, pellets, with silo, 300kW
furnace production, wood chips, average storage area, 1000kW	GLO	2000-2001	furnace, wood chips, average storage area, 1000kW

furnace production, wood chips, average storage area, 1000kW	CH	2000-2001	furnace, wood chips, average storage area, 1000kW
furnace production, wood chips, average storage area, 300kW	GLO	2000-2001	furnace, wood chips, average storage area, 300kW
furnace production, wood chips, average storage area, 300kW	CH	2000-2001	furnace, wood chips, average storage area, 300kW
furnace production, wood chips, average storage area, 50kW	GLO	2000-2001	furnace, wood chips, average storage area, 50kW
furnace production, wood chips, average storage area, 50kW	CH	2000-2001	furnace, wood chips, average storage area, 50kW
furnace production, wood chips, hardwood storage area, 1000kW	GLO	2000-2001	furnace, wood chips, hardwood storage area, 1000kW
furnace production, wood chips, hardwood storage area, 1000kW	CH	2000-2001	furnace, wood chips, hardwood storage area, 1000kW
furnace production, wood chips, hardwood storage area, 300kW	GLO	2000-2001	furnace, wood chips, hardwood storage area, 300kW
furnace production, wood chips, hardwood storage area, 300kW	CH	2000-2001	furnace, wood chips, hardwood storage area, 300kW
furnace production, wood chips, hardwood storage area, 50kW	GLO	2000-2001	furnace, wood chips, hardwood storage area, 50kW
furnace production, wood chips, hardwood storage area, 50kW	CH	2000-2001	furnace, wood chips, hardwood storage area, 50kW
furnace production, wood chips, softwood storage area, 1000kW	GLO	2000-2001	furnace, wood chips, softwood storage area, 1000kW
furnace production, wood chips, softwood storage area, 1000kW	CH	2000-2001	furnace, wood chips, softwood storage area, 1000kW
furnace production, wood chips, softwood storage area, 300kW	GLO	2000-2001	furnace, wood chips, softwood storage area, 300kW
furnace production, wood chips, softwood storage area, 300kW	CH	2000-2001	furnace, wood chips, softwood storage area, 300kW
furnace production, wood chips, softwood storage area, 50kW	GLO	2000-2001	furnace, wood chips, softwood storage area, 50kW
furnace production, wood chips, softwood storage area, 50kW	CH	2000-2001	furnace, wood chips, softwood storage area, 50kW
furnace production, wood chips, with silo, 1000kW	CH; GLO	2010-2011	furnace, wood chips, with silo, 1000kW
furnace production, wood chips, with silo, 5000kW	CH; GLO	2010-2011	furnace, wood chips, with silo, 5000kW
furnace production, wood chips, with silo, 50kW	CH; GLO	2010-2011	furnace, wood chips, with silo, 50kW

12.7 Other updates

A variety of other minor updates were performed between v3.9.1 and v3.10.

In the activity for charcoal production, the amount of the input “cleft timber” was corrected. The amount was calculated dividing the total carbon in the outputs by the carbon content of cleft timber.

In the activity “graphic paper production, 100% recycled “, the water balance was updated.

These datasets, alongside other datasets updated for various reasons are listed in **Table 78**. For more details about what exactly changed in these datasets, you may refer to the Change Report Annex.

Table 78. Datasets updated for v3.10 for a variety of reasons.

Activity Name	Geography	Time Period
charcoal production	GLO	1985-1996
electricity production, compressed air energy storage	GLO; RER	1998-2015
graphic paper production, 100% recycled	GLO; RER	2008-2014
heat and power co-generation unit construction, 1MWel	CH; GLO	2015-2015
market for aluminium, primary, ingot	IAI Area, EU27 & EFTA	2010-2010
market for electric arc furnace dust	Europe without Switzerland	2008-2010
market for electric arc furnace dust	RER	2008-2010
market for electric arc furnace slag	Europe without Switzerland	2008-2010
market for electric arc furnace slag	RER	2008-2010
market for hard coal	ZA	2014-2014
market for mandarin	ZA	2015-2016
market for packaging, for fertilisers	GLO	2009-2015
market for packaging, for fertilisers or pesticides	GLO	2009-2015
market for packaging, for pesticides	GLO	2009-2015
market for sodium nitrate, unrefined	CL	2017-2023
market for sodium nitrate, unrefined	GLO	2015-2018
market for soybean oil, crude	RER	2012-2012
market for wastewater from anaerobic digestion of whey	CH; GLO	2010-2021
market for wastewater from lorry production	CH; GLO	2010-2021
molybdenite mine operation	GLO	1994-2003
paper production, newsprint, virgin	GLO	2000-2000

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14 Annex 1: Products with updated prices

benzene [kg]; butadiene [kg]; cerium oxide [kg]; clay brick [kg]; coal gas [MJ]; coal tar [kg]; coke [MJ]; copper concentrate, sulfide ore [kg]; copper, anode [kg]; dysprosium oxide [kg]; erbium oxide [kg]; ethylene [kg]; europium oxide [kg]; gadolinium oxide [kg]; gravel, crushed [kg]; gravel, round [kg]; holmium oxide [kg]; hydrogen, gaseous [kg]; lanthanum oxide [kg]; lutetium oxide [kg]; molybdenite [kg]; natural gas, high pressure [m3]; natural gas, high pressure, vehicle grade [kg]; natural gas, liquefied [m3]; natural gas, low pressure [m3]; natural gas, low pressure, vehicle grade [kg]; natural gas, medium pressure, vehicle grade [kg]; neodymium oxide [kg]; petroleum [kg]; p-nitrotoluene [kg]; praseodymium oxide [kg]; praseodymium-neodymium oxide [kg]; propylene [kg]; roof tile [kg]; samarium oxide [kg]; samarium-europium-gadolinium oxide [kg]; sand [kg]; scandium oxide [kg]; terbium oxide [kg]; toluene, liquid [kg]; xylene [kg]; ytterbium oxide [kg]; yttrium oxide [kg]

15 Annex 2: 'Chemicals: Harmonisation of proxy inputs' – list of updated datasets

Activity Name in v3.10	Geography	Time Period	Product Name	Unit
1-methoxy-2-propanol production	GLO	2020-2020	1-methoxy-2-propanol	kg
1-naphthylacetic acid production	GLO	2020-2020	1-naphthylacetic acid	kg
2,4-di-tert-butylphenol production	GLO	2015-2020	2,4-di-tert-butylphenol	kg
2,4-dichlorophenol production	GLO; RER	2010-2010	2,4-dichlorophenol	kg
2,4-dichlorotoluene production	GLO; RER	2010-2010	2,4-dichlorotoluene	kg
2,4-dinitrotoluene production	GLO	2015-2020	2,4-dinitrotoluene	kg
2,4-dinitrotoluene production	RER	2015-2020	2,4-dinitrotoluene	kg
2,5-dimethylhexane-2,5-dihydroperoxide production	GLO	2015-2020	2,5-dimethylhexane-2,5-dihydroperoxide	kg
2,6-di-tert-butylphenol production	GLO	2015-2020	2,6-di-tert-butylphenol	kg
2-nitroaniline production	GLO; RER	2010-2010	2-nitroaniline	kg
2-pyridinol production	GLO; RER	2010-2010	2-pyridinol	kg
3-methyl-1-butyl acetate production	GLO; RER	1989-2006	3-methyl-1-butyl acetate	kg
3-methylpyridine production	GLO; RER	2010-2010	3-methylpyridine	kg
4-tert-butylbenzaldehyde production	GLO; RER	2010-2010	4-tert-butylbenzaldehyde	kg
4-tert-butyltoluene production	GLO; RER	2010-2010	4-tert-butyltoluene	kg
6-benzyladenine production	GLO	2020-2020	6-benzyladenine	kg
N-methyl-2-pyrrolidone production	GLO; RER	2015-2020	N-methyl-2-pyrrolidone	kg
acetanilide production	GLO; RER	2010-2010	acetanilide	kg
acetoacetic acid production	GLO; RER	2010-2010	acetoacetic acid	kg
acetone production, from isopropanol	GLO; RER	2015-2020	acetone, liquid	kg
acetyl chloride production	GLO; RER	2010-2010	acetyl chloride	kg
acetylene production	GLO; RER	1991-2020	acetylene	kg
acrolein production	GLO; RER	2010-2010	acrolein	kg
acrylic acid production	RER	1989-2022	acrylic acid	kg
acrylic acid production	GLO	1989-2022	acrylic acid	kg
adipic acid production	GLO; RER	1997-2020	adipic acid	kg
adiponitrile production	GLO	2021-2021	adiponitrile	kg
adiponitrile production	RER	2021-2021	adiponitrile	kg
alkyl sulphate (C12-14) production	GLO	2015-2020	alkyl sulphate (C12-14)	kg

alkylbenzene production, linear	CA-QC; GLO; RER	1995-2020	alkylbenzene, linear	kg
alkylketene dimer sizing agent production, for paper production	GLO; RER	2000-2000	alkylketene dimer sizing agent, for paper production	kg
alpha-naphthol production	GLO; RER	2010-2010	alpha-naphthol	kg
alpha-picoline production	GLO; RER	2010-2010	alpha-picoline	kg
aluminium chloride production	GLO	2015-2020	aluminium chloride	kg
aluminium fluoride production	GLO; RER	2000-2000	aluminium fluoride	kg
amine oxides production	GLO; RER	2015-2020	amine oxides	kg
ammonium carbonate production	GLO; RER	2000-2000	ammonium carbonate	kg
ammonium chloride production	GLO	2012-2012	ammonium chloride	kg
ammonium nitrite production	GLO; RER	2010-2010	ammonium nitrite	kg
ammonium thiocyanate production	GLO	2000-2006	ammonium thiocyanate	kg
aniline production	GLO; RER	2000-2020	aniline	kg
anthranilic acid production	GLO; RER	2010-2010	anthranilic acid	kg
arsine production	GLO	2000-2006	arsine	kg
ascorbic acid production	GLO; RER	2015-2020	ascorbic acid	kg
azodicarbonamide production	GLO; RER	2015-2020	azodicarbonamide	kg
barium hydroxide production	GLO	2015-2020	barium hydroxide	kg
barium oxide production	GLO	2015-2020	barium oxide	kg
barium sulfide production	GLO	2015-2020	barium sulfide	kg
benzal chloride production	GLO; RER	2000-2006	benzal chloride	kg
benzaldehyde production	GLO; RER	2000-2006	benzaldehyde	kg
benzaldehyde-2-sulfonic acid production	GLO	2015-2020	benzaldehyde-2-sulfonic acid	kg
benzoic acid production, toluene oxidation	GLO; RER	2010-2020	benzoic acid	kg
benzyl chloride production	GLO; RER	2000-2006	benzyl chloride	kg
bisphenol A production, powder	GLO; RER	2000-2020	bisphenol A, powder	kg
boric acid production, anhydrous, powder	GLO; RER	2000-2020	boric acid, anhydrous, powder	kg
boric oxide production	GLO	2000-2006	boric oxide	kg
boron carbide production	GLO	2000-2006	boron carbide	kg
boron trifluoride production	GLO	2000-2006	boron trifluoride	kg
bromopropane production	GLO; RER	2010-2010	bromopropane	kg
butyl acetate production	GLO; RER	1991-2020	butyl acetate	kg
butyldiglycol acetate production	GLO	2015-2020	butyldiglycol acetate	kg

calcium carbonate production, precipitated	GLO; RER	2015-2020	calcium carbonate, precipitated	kg
carbon black production	GLO	2000-2020	carbon black	kg
carbon dioxide production, liquid	GLO; RER	1979-2020	carbon dioxide, liquid	kg
carbon disulfide production, from charcoal	GLO	2000-2006	carbon disulfide	kg
carbon disulfide production, from natural gas	GLO	2000-2006	carbon disulfide	kg
carbon monoxide production	GLO; RER	1997-2000	carbon monoxide	kg
cationic resin production	CH; GLO	1997-2020	cationic resin	kg
chlorine dioxide production	GLO; RER	2000-2020	chlorine dioxide	kg
chlormequat chloride production	GLO	2020-2020	chlormequat chloride	kg
chloroacetyl chloride production	GLO; RER	2010-2010	chloroacetyl chloride	kg
chloromethyl methyl ether production	GLO; RER	1979-2002	chloromethyl methyl ether	kg
chloronitrobenzene production	GLO; RER	2010-2010	chloronitrobenzene	kg
chloropropionic acid production	GLO; RER	2010-2010	chloropropionic acid	kg
chromium trioxide production, flakes	GLO; RER	2000-2020	chromium trioxide, flakes	kg
cleaning consumables, without water, in 13.6% solution state	GLO	2011-2013	cleaning consumables, without water, in 13.6% solution state	kg
copper carbonate production	GLO; RER	2000-2000	copper carbonate	kg
copper oxide production	GLO; RER	2000-2020	copper oxide	kg
copper sulfate production	GLO	2006-2012	copper sulfate	kg
cryolite production	GLO; RER	2000-2000	cryolite	kg
cumene production, benzene alkylation	GLO; RER	2000-2000	cumene	kg
cyanoacetic acid production	GLO; RER	2010-2010	cyanoacetic acid	kg
cyanogen chloride production	GLO; RER	2010-2010	cyanogen chloride	kg
cyclohexanol production	GLO; RER	2000-2000	cyclohexanol	kg
cyclohexanone production	GLO; RER	1991-2020	cyclohexanone	kg
daminozide production	GLO	2020-2020	daminozide	kg
decabromodiphenyl ether production	GLO; RER	2015-2020	decabromodiphenyl ether	kg
dichlobenil production	GLO	2021-2021	dichlobenil	kg
diethylenetriaminepentaacetic acid production, alkaline cyanomethylation of diethylenetriamine	GLO; RER	2000-2000	DTPA, diethylenetriaminepentaacetic acid	kg
dimethyl ether production	GLO; RER	2000-2000	dimethyl ether	kg
dimethyl hexanediol production	GLO	2015-2020	dimethyl hexanediol	kg
dimethyl hexynediol production	GLO	2015-2020	dimethyl hexynediol	kg

dimethyl sulfate production	GLO; RER	2000-2000	dimethyl sulfate	kg
dimethyl sulfide production	GLO; RER	2010-2010	dimethyl sulfide	kg
dimethyl sulfoxide production	GLO; RER	2000-2007	dimethyl sulfoxide	kg
dimethylacetamide production	GLO	2000-2020	dimethylacetamide	kg
dimethylamine borane production	GLO	2000-2006	dimethylamine borane	kg
dimethylaminopropylamine production	GLO; RER	2015-2020	dimethylaminopropylamine	kg
dimethyldichlorosilane production	GLO	2015-2020	dimethyldichlorosilane	kg
dinitrogen tetroxide production	GLO	2015-2020	dinitrogen tetroxide	kg
dioctyl adipate production	GLO	2020-2020	dioctyl adipate	kg
dioctyl terephthalate production	GLO	2020-2020	dioctyl terephthalate	kg
dipropyl amine production	GLO; RER	2010-2010	dipropyl amine	kg
dipropylene glycol monomethyl ether production	GLO; RER	2000-2020	dipropylene glycol monomethyl ether	kg
dodecanol production, from coconut oil	GLO	2015-2020	dodecanol	kg
dodecanol production, ziegler process	GLO	2015-2020	dodecanol	kg
electrolyte production, for Li-ion battery	GLO	2019-2020	electrolyte, for Li-ion battery	kg
epoxy resin production, liquid	GLO; RER	2015-2020	epoxy resin, liquid	kg
ethanolamine production	GLO; RER	2000-2020	diethanolamine; monoethanolamine; triethanolamine	kg; kg; kg
ethephon production	GLO	2020-2020	ethephon	kg
ethoxylated alcohol (AE7) production, petrochemical	GLO; RER	1992-2020	ethoxylated alcohol (AE7)	kg
ethyl acetate production	GLO; RER	1991-2020	ethyl acetate	kg
ethyl benzene production	GLO; RER	2000-2000	ethyl benzene	kg
ethylamine production	GLO; RER	2010-2010	ethylamine	kg
ethylene bromide production	GLO; RER	2010-2010	ethylene bromide	kg
ethylene diamine production, from ethanolamine	GLO	2022-2022	ethylene diamine	kg
ethylene diamine production, from ethanolamine	RER	2022-2022	ethylene diamine	kg
ethylene diamine production, from ethylene dichloride	GLO	2022-2022	ethylene diamine	kg
ethylene diamine production, from ethylene dichloride	RER	2022-2022	ethylene diamine	kg
ethylene glycol diethyl ether production	GLO; RER	2000-2007	ethylene glycol diethyl ether	kg
ethylene glycol dimethyl ether production	GLO; RER	2000-2007	ethylene glycol dimethyl ether	kg
ethylene glycol monoethyl ether production	GLO; RER	2000-2006	ethylene glycol monoethyl ether	kg

ethylene vinyl acetate copolymer production	GLO; RER	2000-2000	ethylene vinyl acetate copolymer	kg
ethylenediaminetetraacetic acid production, alkaline cyanomethylation of ethylenediamine	GLO; RER	2000-2020	EDTA, ethylenediaminetetraacetic acid	kg
fluazifop-butyl production	GLO	2021-2021	fluazifop-butyl	kg
folpet production	GLO; RER	2000-2020	folpet	kg
glucose production	GLO; RER	2015-2020	glucose	kg
glycine production	GLO; RER	2010-2010	glycine	kg
glyoxal production	GLO; RER	2010-2010	glyoxal	kg
hexamethylene-1,6-diisocyanate production	GLO	2020-2020	hexamethylene-1,6-diisoncyanate	kg
hexamethylene-1,6-diisocyanate production	RER	2020-2020	hexamethylene-1,6-diisoncyanate	kg
hexamethylenediamine production	GLO	2021-2021	hexamethylenediamine	kg
hexamethylenediamine production	RER	2021-2021	hexamethylenediamine	kg
hydrazine production	GLO; RER	2010-2010	hydrazine	kg
hydrazine sulfate production	GLO	2015-2020	hydrazine sulfate	kg
hydrochloric acid production, from the reaction of hydrogen with chlorine	GLO; RER	1997-2020	hydrochloric acid, without water, in 30% solution state	kg
hydroquinone production	GLO; RER	2010-2010	hydroquinone	kg
hydroxylamine production	GLO; RER	2010-2020	hydroxylamine	kg
imidazole production	GLO; RER	2010-2010	imidazole	kg
indolylbutyric acid production	GLO	2020-2020	indolylbutyric acid	kg
ioxynil production	GLO	2021-2021	ioxynil	kg
isophorondiisocyanate production	GLO	2020-2020	isophorondiisocyante	kg
isophorondiisocyanate production	RER	2020-2020	isophorondiisocyante	kg
isopropanol production	GLO; RER	2000-2020	isopropanol	kg
isopropylamine production	GLO; RER	2010-2010	isopropylamine	kg
lactic acid production	GLO; RER	2010-2010	lactic acid	kg
lauric diethanolamide production	GLO	2021-2021	lauric diethanolamide	kg
lithium chloride production	GLO	2000-2006	lithium chloride	kg
lithium hydroxide production	GLO	2000-2020	lithium hydroxide	kg
lithium production, lithium chloride electrolysis	GLO	2000-2006	lithium	kg
lithium sulfate production	GLO	2020-2020	lithium sulfate	kg
lubricating oil production	GLO; RER	2000-2020	lubricating oil	kg
maleic hydrazide production	GLO	2020-2020	maleic hydrazide	kg

maneb production	GLO	2021-2021	maneb	kg
melamine production	GLO; RER	2000-2020	melamine	kg
mepiquat chloride production	GLO	2020-2020	mepiquat chloride	kg
metazachlor production	GLO	2021-2021	metazachlor	kg
methallylchloride production	GLO	2021-2021	methallylchloride	kg
methyl acrylate production	GLO	2000-2006	methyl acrylate	kg
methyl ethyl ketone production	GLO; RER	2000-2020	methyl ethyl ketone	kg
methyl formate production	GLO; RER	2003-2006	methyl formate	kg
methyl iodide production	GLO; RER	2010-2010	methyl iodide	kg
methyl-3-methoxypropionate production	GLO	2000-2006	methyl-3-methoxypropionate	kg
methylsulfonic acid production	GLO; RER	2010-2010	methylsulfonic acid	kg
morpholine production	GLO	2015-2020	morpholine	kg
n-olefins production	GLO; RER	1995-1995	n-olefins	kg
naphthalene sulfonic acid production	GLO; RER	2010-2020	naphthalene sulfonic acid	kg
nickel sulfate production	GLO	2006-2020	nickel sulfate	kg
nitric oxide production	GLO	2015-2020	nitric oxide	kg
nitrobenzene production	GLO; RER	1997-2000	nitrobenzene	kg
nitrous dioxide production	GLO; RER	2010-2010	nitrous dioxide	kg
nitrous oxide production	GLO; RER	2010-2010	nitrous oxide	kg
non-ionic surfactant production, ethylene oxide derivate	GLO	2015-2020	non-ionic surfactant	kg
non-ionic surfactant production, fatty acid derivate	GLO	2015-2020	non-ionic surfactant	kg
o-aminophenol production	GLO; RER	2010-2010	o-aminophenol	kg
o-chlorotoluene production	GLO; RER	2010-2010	o-chlorotoluene	kg
o-cresol production	GLO; RER	2010-2010	o-cresol	kg
o-nitrophenol production	GLO; RER	2010-2010	o-nitrophenol	kg
octabenzone production	GLO	2015-2020	octabenzone	kg
ozone production, liquid	GLO; RER	2000-2020	ozone, liquid	kg
p-chlorophenol production	GLO; RER	2010-2010	p-chlorophenol	kg
p-nitrophenol production	GLO; RER	2010-2010	p-nitrophenol	kg
paraffin production	GLO; RER	1995-1995	paraffin	kg
phenolic resin production	GLO; RER	2000-2020	phenolic resin	kg
phenyl acetic acid production	GLO; RER	2010-2010	phenyl acetic acid	kg
phenyl isocyanate production	GLO; RER	2010-2010	phenyl isocyanate	kg

phosgene production, liquid	GLO; RER	2000-2000	phosgene, liquid	kg
phosphane production	GLO	2000-2020	phosphane	kg
phosphorous chloride production	GLO; RER	2000-2000	phosphorous chloride	kg
phosphorus oxychloride production, from phosphorus pentachloride	GLO	2015-2020	phosphorus oxychloride	kg
phosphorus oxychloride production, from phosphorus trichloride	GLO; RER	2000-2020	phosphorus oxychloride	kg
phosphorus trichloride production	GLO	2015-2020	phosphorus trichloride	kg
phthalimide production	GLO; RER	2010-2010	phthalimide	kg
piperidine production	GLO; RER	2010-2010	piperidine	kg
plasticiser production, for concrete, based on sulfonated melamine formaldehyde	GLO	2014-2014	plasticiser, for concrete, based on sulfonated melamine formaldehyde	kg
polyacrylamide production	GLO	2012-2012	polyacrylamide	kg
polyaluminium chloride production	GLO	2015-2020	polyaluminium chloride	kg
polydimethylsiloxane production	GLO	2015-2020	polydimethylsiloxane	kg
polysulfone production, for membrane filtration production	GLO	2012-2012	polysulfone	kg
potassium carbonate production, from potassium hydroxide	GLO	2000-2020	potassium carbonate	kg
potassium perchlorate production	GLO	2000-2006	potassium perchlorate	kg
potassium permanganate production, manganese dioxide oxidation	GLO; RER	1990-2020	potassium permanganate	kg
prochloraz production	GLO	2021-2021	prochloraz	kg
propionic acid production	GLO; RER	2010-2010	propionic acid	kg
propyl acetate production	GLO; RER	2010-2010	isopropyl acetate	kg
propyl amine production	GLO; RER	2010-2010	propyl amine	kg
propylene glycol production, liquid	GLO; RER	2000-2000	propylene glycol, liquid	kg
propylene oxide production, liquid	GLO; RER	2000-2000	propylene oxide, liquid	kg
pyrazole production	GLO; RER	2010-2010	pyrazole	kg
regenerative thermal oxidation of nitrous oxide	GLO; RER	2022-2022	N2O retained, by regenerative thermal oxidation	kg
retention aid production, for paper production	GLO; RER	2000-2000	retention aid, for paper production	kg
selenium production	GLO; RER	2000-2020	selenium	kg
soap production	GLO; RER	1992-2020	soap	kg
soda ash production, dense, Hou's process	GLO	2000-2006	soda ash, dense	kg
sodium aluminate production, powder	GLO	2012-2012	sodium aluminate, powder	kg
sodium amide production	GLO; RER	2010-2010	sodium amide	kg

sodium arsenide production from Imperial smelting furnace	GLO	2000-2010	sodium arsenide	kg
sodium chloroacetate production	GLO	2015-2020	sodium chloroacetate	kg
sodium cumenesulphonate production	GLO; RER	2015-2020	sodium cumenesulphonate	kg
sodium dithionite production, anhydrous	GLO; RER	2000-2020	sodium dithionite, anhydrous	kg
sodium ethoxide production	GLO; RER	2010-2010	sodium ethoxide	kg
sodium fluoride production	GLO	1980-1980	sodium fluoride	kg
sodium formate production	GLO	1950-2020	sodium formate	kg
sodium hydrogen sulfate production	GLO	2015-2020	sodium hydrogen sulfate	kg
sodium hydrogen sulfite production	GLO; RER	2010-2020	sodium hydrogen sulfite	kg
sodium hydrosulfide production	GLO; RER	2010-2010	sodium hydrosulfide	kg
sodium nitrate production	GLO; RER	2010-2020	sodium nitrate	kg
sodium nitrite production	GLO; RER	2010-2010	sodium nitrite	kg
sodium oxide production	GLO; RER	2015-2020	sodium oxide	kg
sodium perchlorate production	GLO	2000-2006	sodium perchlorate	kg
sodium persulfate production	GLO	2000-2020	sodium persulfate	kg
sodium phenolate production	GLO; RER	2010-2010	sodium phenolate	kg
sodium production, sodium chloride electrolysis, molten salt cell	GLO; RER	2010-2010	sodium	kg
sodium pyrophosphate production	GLO	2012-2020	sodium pyrophosphate	kg
sodium silver thiosulfate production	GLO	2020-2020	sodium silver thiosulfate	kg
sodium sulfite production	GLO; RER	2010-2020	sodium sulfite	kg
sodium tetrafluoroborate production	GLO	2002-2002	sodium tetrafluoroborate	kg
sodium tetrafluoroborate production, sodium tetrahydridoborate fluorination	GLO	2000-2020	diborane	kg
succinic acid production	GLO	2015-2020	succinic acid	kg
sulfamic acid production	GLO	2015-2020	sulfamic acid	kg
sulfur dichloride production	GLO; RER	2010-2010	sulfur dichloride	kg
sulfur dioxide production, liquid	GLO; RER	1997-2020	sulfur dioxide, liquid	kg
sulfur trioxide production	GLO; RER	2000-2000	sulfur trioxide	kg
sulfuryl chloride production	GLO	2002-2002	sulfuryl chloride	kg
t-butyl amine production	GLO; RER	2010-2010	t-butyl amine	kg
tetraethyl orthosilicate production	GLO	2013-2013	tetraethyl orthosilicate	kg
tin dioxide production	GLO	2001-2001	tin dioxide	kg
trichloroacetic acid production	GLO; RER	2010-2010	trichloroacetic acid	kg
trichloroborane production	GLO	2000-2006	trichloroborane	kg

triethyl amine production	GLO; RER	2010-2010	triethyl amine	kg
trifluoroacetic acid production	GLO; RER	2010-2010	trifluoroacetic acid	kg
trifluoromethane production	GLO	2000-2006	trifluoromethane	kg
trimesoyl chloride production, for membrane filtration production	GLO	2012-2012	trimesoyl chloride	kg
trimethyl borate production	GLO	2000-2020	trimethyl borate	kg
trimethylamine production	GLO; RER	1991-2002	trimethylamine	kg
triphenyl phosphate production	GLO	2015-2020	triphenyl phosphate	kg
tris(2,4-ditert-butylphenyl) phosphite production	GLO	2015-2020	tris(2,4-ditert-butylphenyl) phosphite	kg
trisodium phosphate production	GLO	2015-2020	trisodium phosphate	kg
vinyl acetate production	GLO; RER	2000-2000	vinyl acetate	kg
vinyl carbonate production	GLO	2020-2020	vinyl carbonate	kg
white spirit production	GLO; RER	2000-2020	white spirit	kg
zinc oxide production	GLO; RER	2005-2020	zinc oxide	kg
zineb production	GLO	2021-2021	zineb	kg