Documentation of changes implemented in the ecoinvent database v3.4
(2017.10.04)

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1 Introduction

This report covers the changes to the ecoinvent database between version 3.3, released in 2016 and version 3.4, released in 2017. It describes both database-wide changes that affect the whole database as well as specific changes in the different sectors. These changes are the addition of new datasets, the deletion of outdated ones, and the re-modelling or corrections of others.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.

For a full comparison between the versions of the database, consisting of a listing of all flows affected by changes and the actual amounts changed, the Change Report Annex can be downloaded as an excel file from the ecoinvent website by license holders only.

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

2 Database-wide changes

2.1 Renamed exchanges and activities

Some activities or products were renamed for version 3.4. The changes are listed in the following tables, and also treated in the following chapters if associated to a change in the modelling.

Table 1. Intermediate exchanges renamed for version 3.4. *Most of the changes aim to improve the product name, or to prepare the database to receive new technologies in the upcoming versions. More details about heat from steam are given in Chapter 5.3).*

Name of exchange in version 3.3	Name of exchange in version 3.4
copper concentrate	copper concentrate, sulfide ore
heat, in chemical industry	heat, from steam, in chemical industry

Table 2. Activities renamed for v3.4. *Most of the changes aim to better define the scope of the activity. More details of some changes (ie. steam) are given in the corresponding chapters.*

Activity name in v3.3	Activity name in v3.4
copper mine operation	copper mine operation, sulfide ore
hard coal mine operation	hard coal mine operation and hard coal preparation
market for copper concentrate	market for copper concentrate, sulfide ore
market for heat, in chemical industry	market for heat, from steam, in chemical industry
steam production in chemical industry	steam production, as energy carrier, in chemical industry
treatment of biowaste, composting	treatment of biowaste, industrial composting

2.2 Price change

For some products, prices were updated in v3.4, and are listed here. Mentions to other changes affecting those products will be made in the rest of the report.

Of course, all newly introduced products (except wastes) have price information.

Table 3. *List of products whose price was updated from v3.3 to v3.4.*

Product name
acetone, liquid
blast furnace slag
cadmium sludge from zinc electrolysis
compost
drying of maize grain
hydrochloric acid, without water, in 30% solution state
hydrogen, liquid
lime
municipal solid waste
potassium carbonate
poultry manure, fresh
sulfur
sulfuric acid
water, decarbonised, at user

2.3 Changes on Impact Assessment

No new impact assessment methods were implemented for version 3.4. However, a few mistakes in the implementation of 3.3 were corrected:

• In the "ecological footprint" method, "total" category and "total" indicator, CFs were the twice as high as what they should be.

• In the method "ecological scarcity 2016", heavy metal emissions to soil, industrial subcompartment, should have been zero, as they the method does not assume transfer to water and ingestion through other mechanism.

• In the method "ecological scarcity 2016", there is no legal limit of dioxins to water in the subcompartment groundwater, groundwater long term and ocean, so their CFs should have been zero

The details of the changes are reported in the "LCIA changes" tab of the Change Repot Annex.

3 Electricity: market mixes

With v3.4, the user has access to updated and new market mixes for electricity (high, medium and low voltage), based on latest available statistical data. This update and extension of the electricity sector is focused on electricity markets.

In the attributional system models, market compositions are based on production volumes for year 2014 (primary data source: IEA, 2017) and are available for all 142 countries which are part of the IEA statistics. That means that with v3.4, 100% of (statistically represented) global electricity generation is covered by country-specific market data.

The consequential system model ("substitution, consequential, long-term") contains new, specific electricity market compositions for 40 countries, based on projections from the EU and the IEA (primary data sources: EC, 2016; IEA, 2016). The market compositions of all other geographies are equivalent to the RoW market composition. These new markets are a significant improvement of the consequential system model and provide a consistent basis for electricity supply in consequential LCA; they are listed in Table 4. It has to be noted that, due to the insufficient availability of consistent data, imports are not taken into account in the composition of the market mix in the consequential system model. As this was already the case in previous versions, this does not subtract from the quality of the new data but it remains a limitation of the projection data.

The market mixes are now generated by directly editing the contribution of the producing activities to the markets, in the market activity itself. This is being done in v3.4 for electricity, and might be used for other markets in following releases. Electricity mixes are therefore not composed in the way described in the Data Quality Guidelines of ecoinvent version 3, section 4.3. That type of operation makes the values of Production Volumes in the activities redundant; some of the new activities generated for this release bear production volumes of 0. Similarly, the Technology Level is not anymore deciding on which activities contribute to which market in the consequential system model. More detailed information regarding methodology for specification of market compositions in all system models, electricity generation activities used, geographical coverage, etc. are provided in Bauer et al., 2017. Users can also check the excel document "Electricity Market Composition_v3.4" to verify market compositions of the electricity sector in the different system models. This excel file is accessible after logging in our webpage, in the ecoQuery.

Table 4. Countries where a specific marginal electricity mix has been defined. **To simplify, Russia is mentioned solely in the list of countries located outside of the European continent.*

Countries in the European continent	Countries outside of the European continent
Austria	Australia
Belgium	Brazil
Bulgaria	Canada
Croatia	Chile
Cyprus	China
Czech Republic	India
Denmark	Japan
Estonia	Russia*
Finland	South Africa
Belgium	United-States
Bulgaria	
Croatia	
Cyprus	
Czech Republic	
Denmark	
Estonia	
Finland	
France	
Germany	
Greece	
Hungary	
Ireland	
Italy	
Latvia	
Lithuania	
Luxembourg	
Malta	
Netherlands	
Norway	
Poland	
Portugal	
Romania	
Slovakia	
Slovenia	
Spain	
Sweden	
Switzerland	
United Kingdom	

Table 5. New and updated market activities for electricity. *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 v3.4, "N" stands for "New", "U" stands for "Updated". New high voltage electricity markets are supplied by RoW electricity generation activities.*

Activity Name	Geography	Time period	V3.4
market for electricity, high voltage	AE; AL; AM; AO; AR; AZ; BD; BH; BJ; BN; BO; BW; BY; CD; CG; CI; CM; CO; CR; CU; CW; DO; DZ; EC; EG; ER; ET; GA; GE; GH; GI; GT; HK; HN; HT; IL; IQ; JM; JO; KE; KG; KH; KP; KW; KZ; LB; LK; LY; MA; MD; ME; MM; MN; MU; MZ; NE; NG; NI; NP; NZ; OM; PA; PH; PK; PY; QA; SD; SG; SN; SS; SV; SY; TG; TJ; TM; TN; TT; UY; UZ; VE; VN; XK; YE; ZM; ZW	2014 - 2017	**N**
market for electricity, high voltage	ASCC; AT; AU; BA; BE; BG; BR; 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; CL; CSG; CY; CZ; DE; DK; EE; ES; FI; FR; FRCC; GB; GLO; GR; HICC; HR; HU; ID; IE; IR; IS; IT; JP; KR; LT; LU; LV; MK; MRO, US only; MT; MX; MY; NL; NO; NPCC, US only; PE; PL; PT; RFC; RO; RS; RU; SA; SE; SERC; SGCC; SI; SK; SPP; TH; TR; TRE; TW; TZ; UA; WECC, US only; ZA	2014 - 2017	**U**
market for electricity, medium voltage	AE; AL; AM; AO; AR; AZ; BD; BH; BJ; BN; BO; BW; BY; CD; CG; CI; CM; CO; CR; CU; CW; DO; DZ; EC; EG; ER; ET; GA; GE; GH; GI; GT; HK; HN; HT; IL; IQ; JM; JO; KE; KG; KH; KP; KW; KZ; LB; LK; LY; MA; MD; ME; MM; MN; MU; MZ; NE; NG; NI; NP; NZ; OM; PA; PH; PK; PY; QA; SD; SG; SN; SS; SV; SY; TG; TJ; TM; TN; TT; UY; UZ; VE; VN; XK; YE; ZM; ZW	2014 - 2017	**N**
market for electricity, medium voltage	ASCC; AT; AU; BA; BE; BG; BR; 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; CL; CSG; CY; CZ; DE; DK; EE; ES; FI; FR; FRCC; GB; GLO; GR; HICC; HR; HU; ID; IE; IR; IS; IT; JP; KR; LT; LU; LV; MK; MRO, US only; MT; MX; MY; NL; NO; NPCC, US only; PE; PL; PT; RFC; RO; RS; RU; SA; SE; SERC; SGCC; SI; SK; SPP; TH; TR; TRE; TW; TZ; UA; WECC, US only; ZA	2014 - 2017	**U**
market for electricity, low voltage	AE; AL; AM; AO; AR; AZ; BD; BH; BJ; BN; BO; BW; BY; CD; CG; CI; CM; CO; CR; CU; CW; DO; DZ; EC; EG; ER; ET; GA; GE; GH; GI; GT; HK; HN; HT; IL; IQ; JM; JO; KE; KG; KH; KP; KW; KZ; LB; LK; LY; MA; MD; ME; MM; MN; MU; MZ; NE; NG; NI; NP; NZ; OM; PA; PH; PK; PY; QA; SD; SG; SN; SS; SV; SY; TG; TJ; TM; TN; TT; UY; UZ; VE; VN; XK; YE; ZM; ZW	2014 - 2017	**N**
market for electricity, low voltage	ASCC; AT; AU; BA; BE; BG; BR; 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; CL; CSG; CY; CZ; DE; DK; EE; ES; FI; FR; FRCC; GB; GLO; GR; HICC; HR; HU; ID; IE; IR; IS; IT; JP; KR; LT; LU; LV; MK; MRO, US only; MT; MX; MY; NL; NO; NPCC, US only; PE; PL; PT; RFC; RO; RS; RU; SA; SE; SERC; SGCC; SI; SK; SPP; TH; TR; TRE; TW; TZ; UA; WECC, US only; ZA	2014 - 2017	**U**

The markets for label-certified electricity have also been updated, and are taken into account by this change.

3.1 New and updated activities on electricity and heat production

In order to cover all 142 countries, take into account latest statistical data, and represent the marginal suppliers needed in the consequential modelling, many new activities have been added or updated in the v3.4 database, they are represented in the tables below. Updates covered exchange correction, adjustment of time period, and/or adjustment of production volumes to avoid mismatches with the market mix. Details regarding why and how these activities were generated are provided in Bauer et al., 2017.

The case of India, where the electricity production is in v3.4 modelled per state and grouped in five markets each representing one sub-national grid, is excluded from this chapter and covered in the following one, dedicated exclusively to this update.

Table 6. New activities on electricity production in v3.4 (excluding India). *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	Reference Product
electricity production, deep geothermal	CL; CN-GD; CN-SH; CZ; FR; GB; HU; LT; LV; PL; SERC; ZA	2016 - 2018	electricity, high voltage
electricity production, hard coal	EE; MX	1980 - 2015	electricity, high voltage
electricity production, hard coal	LV; RU	2016 - 2018	electricity, high voltage
electricity production, hydro, reservoir, alpine region	CL	1945 - 2030	electricity, high voltage
electricity production, hydro, reservoir, alpine region	LV	2016 - 2018	electricity, high voltage
electricity production, hydro, reservoir, non-alpine region	CA-PE	1945 - 2015	electricity, high voltage
electricity production, hydro, run-of-river	CA-PE; NP	1945 - 2015	electricity, high voltage
electricity production, hydro, run-of-river	CN-SH; ZA	2016 - 2018	electricity, high voltage
electricity production, lignite	RU	2016 - 2018	electricity, high voltage
electricity production, lignite	UA	2008 - 2008	electricity, high voltage
electricity production, natural gas, combined cycle power plant	BG; CH; CY; LU; LV; MT; PL; RO; SE; SI; ZA	2016 - 2018	electricity, high voltage
electricity production, natural gas, conventional power plant	CA-PE	1990 - 2015	electricity, high voltage
electricity production, nuclear, pressure water reactor	CN-SH; LT; LV	2016 - 2018	electricity, high voltage
electricity production, oil	LU; PL	2016 - 2018	electricity, high voltage
electricity production, oil	NP	1980 - 2015	electricity, high voltage
electricity production, peat	LT	1980 - 2015	electricity, high voltage
electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted	BR; CL; CN-BJ; CN-CQ; CN-GX; CN-HB; CN-HE; CN-HL; CN-HN; CN-JL; CN-LN; CN-SCCN-TJ; HR; IE; LV; MK; NP; RS; RU; TR	2016 - 2018	electricity, low voltage
electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted	CL; CN-BJ; CN-CQ; CN-GX; CN-HB; CN-HE; CN-HL; CN-HN;	2005 - 2015	electricity, low voltage

Activity Name	Geography	Time Period	Reference Product
	CN-JL; CN-SC; CN-TJ; HRMK; RS; RU; TR		
electricity production, photovoltaic, 570kWp open ground installation, multi-Si	BE; CN-BJ; CN-CQ; CN-GX; CN-HB; CN-HE; CN-HL; CN-HN; CN-JL; CN-LN; CN-SC; CN-TJSE	2008 - 2015	electricity, low voltage
electricity production, wind, 1-3MW turbine, offshore	EE; PL	2016 - 2018	electricity, high voltage
electricity production, wind, 1-3MW turbine, onshore	MK; NP	2005 - 2015	electricity, high voltage
electricity production, wind, >3MW turbine, onshore	CH; CY; LV; SI	2016 - 2018	electricity, high voltage
electricity production, wood, future	GLO	2016 - 2030	electricity, high voltage
electricity voltage transformation from high to medium voltage	AE; AL; AM; AO; AR; AZ; BD; BH; BJ; BN; BO; BW; BY; CD; CG; CI; CM; CO; CR; CU; CW; DO; DZ; EC; EG; ER; ET; GA; GE; GH; GI; GT; HK; HN; HT; IL; IQ; JM; JO; KE; KG; KH; KP; KW; KZ; LB; LK; LY; MA; MD; ME; MM; MN; MU; MZ; ; NE; NG; NI; NP; NZ; OM; PA; PH; PK; PY; QA; SD; SG; SN; SS; SV; SY; TG; TJ; TM; TN; TT; UY; UZ; VE; VN; XK; YE; ZM; ZW	2012 - 2012	electricity, medium voltage
electricity voltage transformation from medium to low voltage	AE; AL; AM; AO; AR; AZ; BD; BH; BJ; BN; BO; BW; BY; CD; CG; CI; CM; CO; CR; CU; CW; DO; DZ; EC; EG; ER; ET; GA; GE; GH; GI; GT; HK; HN; HT; IL; IQ; JM; JO; KE; KG; KH; KP; KW; KZ; LB; LK; LY; MA; MD; ME; MM; MN; MU; MZ; NE; NG; NI; NP; NZ; OM; PA; PH; PK; PY; QA; SD; SG; SN; SS; SV; SY; TG; TJ; TM; TN; TT; UY; UZ; VE; VN; XK; YE; ZM; ZW;	2012 - 2012	electricity, low voltage
electricity, high voltage, import from AL	GR; ME	2012 - 2012	electricity, high voltage
electricity, high voltage, import from AL	RS	2012 - 2012	electricity, high voltage
electricity, high voltage, import from AO	CD	2012 - 2012	electricity, high voltage
electricity, high voltage, import from BA	HR; ME; RS	2012 - 2012	electricity, high voltage
electricity, high voltage, import from BG	MK; TR	2012 - 2012	electricity, high voltage
electricity, high voltage, import from BR	AR	2012 - 2012	electricity, high voltage

Activity Name	Geography	Time Period	Reference Product
electricity, high voltage, import from BY	LT	2012 - 2012	electricity, high voltage
electricity, high voltage, import from CD	CG; GA	2012 - 2012	electricity, high voltage
electricity, high voltage, import from CO	EC	2012 - 2012	electricity, high voltage
electricity, high voltage, import from CR	NI; PA	2012 - 2012	electricity, high voltage
electricity, high voltage, import from CSG	HK	2012 - 2012	electricity, high voltage
electricity, high voltage, import from DZ	MA; TN	2012 - 2012	electricity, high voltage
electricity, high voltage, import from EE	RU	2012 - 2012	electricity, high voltage
electricity, high voltage, import from FR	LU	2012 - 2012	electricity, high voltage
electricity, high voltage, import from GE	AM; AZ	2012 - 2012	electricity, high voltage
electricity, high voltage, import from GH	TG	2012 - 2012	electricity, high voltage
electricity, high voltage, import from GR	AL; BG	2012 - 2012	electricity, high voltage
electricity, high voltage, import from GT	SV	2012 - 2012	electricity, high voltage
electricity, high voltage, import from HN	GT	2012 - 2012	electricity, high voltage
electricity, high voltage, import from HR	HU	2012 - 2012	electricity, high voltage
electricity, high voltage, import from HR	RS	2012 - 2012	electricity, high voltage
electricity, high voltage, import from ID	MY	2012 - 2012	electricity, high voltage
electricity, high voltage, import from IN-Northern grid	NP	2012 - 2015	electricity, high voltage
electricity, high voltage, import from IQ	TR	2012 - 2012	electricity, high voltage
electricity, high voltage, import from IR	IQ	2012 - 2012	electricity, high voltage
electricity, high voltage, import from KZ	UZ	2012 - 2012	electricity, high voltage
electricity, high voltage, import from LT	BY; LV; RU	2012 - 2012	electricity, high voltage
electricity, high voltage, import from LV	EE; LT	2012 - 2012	electricity, high voltage
electricity, high voltage, import from MA	DZ	2012 - 2012	electricity, high voltage
electricity, high voltage, import from ME	AL; BA; RS	2012 - 2012	electricity, high voltage
electricity, high voltage, import from MK	RS	2012 - 2012	electricity, high voltage
electricity, high voltage, import from NG	BJ; NE	2012 - 2012	electricity, high voltage
electricity, high voltage, import from NI	HN	2012 - 2012	electricity, high voltage
electricity, high voltage, import from PA	CR	2012 - 2012	electricity, high voltage
electricity, high voltage, import from RO	MD; UA	2012 - 2012	electricity, high voltage
electricity, high voltage, import from RS	AL; HU; ME; RO; XK	2012 - 2012	electricity, high voltage
electricity, high voltage, import from RU	BY; GE	2012 - 2012	electricity, high voltage
electricity, high voltage, import from SA	BH; JO	2012 - 2012	electricity, high voltage
electricity, high voltage, import from SGCC	MN	2012 - 2012	electricity, high voltage
electricity, high voltage, import from SY	LB	2012 - 2012	electricity, high voltage
electricity, high voltage, import from TG	GH	2012 - 2012	electricity, high voltage
electricity, high voltage, import from TH	VN	2012 - 2012	electricity, high voltage
electricity, high voltage, import from TN	LY	2012 - 2012	electricity, high voltage
electricity, high voltage, import from TZ	KE	2012 - 2012	electricity, high voltage
electricity, high voltage, import from UA	BY; SK	2012 - 2012	electricity, high voltage
electricity, high voltage, import from UZ	KG; KZ; TJ	2012 - 2012	electricity, high voltage
electricity, high voltage, import from VE	CO	2012 - 2012	electricity, high voltage

Activity Name	Geography	Time Period	Reference Product
electricity, high voltage, import from VN	KH	2012 - 2012	electricity, high voltage
electricity, high voltage, import from ZA	BW; MZ; ZW	2012 - 2012	electricity, high voltage
electricity, high voltage, import from ZW	ZM	2012 - 2012	electricity, high voltage
heat and power co-generation, biogas, gas engine	BG; CL; CY; ID	2007 - 2015	electricity, high voltage

Table 7. Updated activities on electricity production. *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	Reference Product
electricity production, hydro, run-of-river	SI	2016 - 2018	electricity, high voltage
electricity production, natural gas, combined cycle power plant	NL; RU	2016 - 2018	electricity, high voltage
electricity production, nuclear, pressure water reactor	JP; RO	2016 - 2018	electricity, high voltage
electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted	CA-ON; CH; CN-SH; DK; FI; GB; HU; LU; MT	2016 - 2018	electricity, low voltage
electricity production, wind, 1-3MW turbine, offshore	GLO	2000 - 2015	electricity, high voltage
electricity production, wind, 1-3MW turbine, offshore	GLO	2005 - 2015	electricity, high voltage
electricity production, wind, >3MW turbine, onshore	CZ; HR; LU; PT; RU; SK	2016 - 2018	electricity, high voltage

Table 8. New and updated activities on heat and power co-generation in v3.4. *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 v3.4, "N" stands for "New", "U" stands for "Updated".*

Activity Name	Geography	Time Period	Reference Product	V3.4
heat and power co-generation, hard coal	BG; IT; TR; TW; UA	1980 - 2015	heat, district or industrial, other than natural gas	N
heat and power co-generation, lignite	AU; BA; BG; HU; RO; RS; TR	1980 - 2015	heat, district or industrial, other than natural gas	N
heat and power co-generation, natural gas, combined cycle power plant, 400MW electrical	NO	2000 - 2015	heat, district or industrial, natural gas	N
heat and power co-generation, natural gas, conventional power plant, 100MW electrical	CA-PE; NO	1990 - 2015	heat, district or industrial, natural gas	N
heat and power co-generation, oil	EE; HU; SI	1980 - 2015	heat, district or industrial, other than natural gas	N
heat and power co-generation, wood chips, 6667 kW	CH	2010 – 2015	heat, district or industrial, other than natural gas	U
heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014	BG; CL; CN-GD; CN-SH; EE; GR; HR; LU; LV; RU; ZA	2010 – 2015	heat, district or industrial, other than natural gas	N
heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014	ASCC; CA-ON; CH; CY; HICC; MT; SERC; SPP	2010 - 2015	heat, district or industrial, other than natural gas	U

The activity "heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014, CN, 2010 – 2015" was deleted, as its being replaced by two representative provinces.

4 Electricity: new data on India

Large countries can show significant differences in electricity production and consumption mixes across their territories. For this reason, ecoinvent has in the past partitioned the United States, Canada and China into electricity grid networks and provinces. This year's release of the ecoinvent database includes the splitting of the country of India which, with its booming economy, is becoming more and more important in the assessment of the supply chain of numerous products. India is partitioned into 29 states grouped in 5 electricity grids Northern, North-eastern, Eastern, Southern, and Western. Table 9 lists all newly added states grouped by electricity grid.

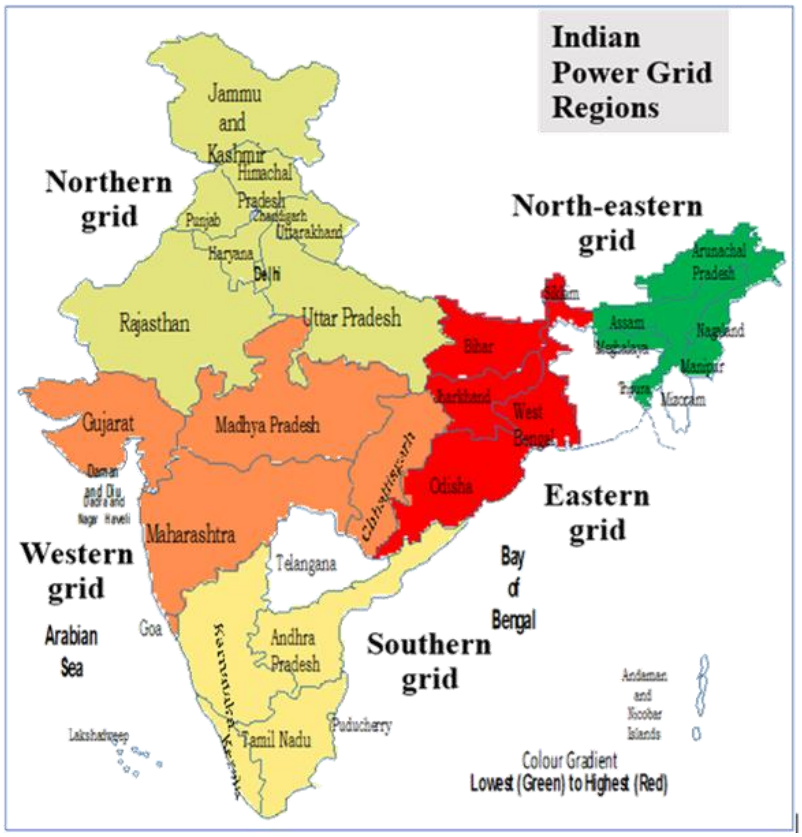

Figure 1. *Map of the Indian power grid regions. Map taken from Hossain, 2017 with permission of the author. The map was elaborated by the author over a freely accessible template of India, provided by https://indzara.com/2013/04/geographic-heat-map-india-excel-template/*

Table 9. List of Indian states names and shortcuts grouped by electricity grid.

State name	State shortcut	Electricity gird
IN-Delhi	IN-DL	IN-Northern grid
IN-Haryana	IN-HR	IN-Northern grid
IN-Himachal Pradesh	IN-HP	IN-Northern grid
IN-Jammu and Kashmir	IN-JK	IN-Northern grid
IN-Punjab	IN-PB	IN-Northern grid
IN-Rajasthan	IN-RJ	IN-Northern grid
IN-Uttar Pradesh	IN-UP	IN-Northern grid
IN-Uttarakhand	IN-UT	IN-Northern grid
IN-Arunachal Pradesh	IN-AR	IN-North-eastern grid
IN-Assam	IN-AS	IN-North-eastern grid
IN-Manipur	IN-MN	IN-North-eastern grid
IN-Meghalaya	IN-ML	IN-North-eastern grid
IN-Nagaland	IN-NL	IN-North-eastern grid
IN-Tripura	IN-TR	IN-North-eastern grid
IN-Andaman and Nicobar	IN-AN	IN-Eastern grid
IN-Bihar	IN-BR	IN-Eastern grid
IN-Jharkhand	IN-JH	IN-Eastern grid
IN-Orissa	IN-OR	IN-Eastern grid
IN-Sikkim	IN-SK	IN-Eastern grid
IN-West Bengal	IN-WB	IN-Eastern grid
IN-Andhra Pradesh	IN-AP	IN-Southern grid
IN-Karnataka	IN-KA	IN-Southern grid
IN-Kerala	IN-KL	IN-Southern grid
IN-Lakshadweep	IN-LD	IN-Southern grid
IN-Puducherry	IN-PY	IN-Southern grid
IN-Tamil Nadu	IN-TN	IN-Southern grid
IN-Chhattisgarh	IN-CT	IN-Western grid
IN-Goa	IN-GA	IN-Western grid
IN-Gujarat	IN-GJ	IN-Western grid
IN-Madhya Pradesh	IN-MP	IN-Western grid

For each state, the relevant electricity producing technologies were created with specific information, where possible, on key emissions, fuel consumption and/or thermal efficiency. These technologies then feed into the market for the respective grid. Following the structure of the electricity sector in ecoinvent (Treyer and Bauer, 2016), the activities for transformation of electricity voltage from high to medium and from medium to low are reported for all 5 grids. Additionally, datasets were created to model imports from neighbouring countries and amongst grids.

Users interested in a specific geographic location in India will benefit from this split, while users working at country level will be able to continue to do so using the market group activities for India. The activities “market for electricity, high voltage”, “market for electricity, medium voltage”, and “market for electricity, low voltage” are replaced by the activities “market group for electricity, high voltage”, “market group for electricity, medium voltage”, and “market group for electricity, low

voltage". Please mind that certain technologies, such as "electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted", have been deleted due to their low production volume or irrelevance. Find the complete list of deleted activities in Table 10.

Table 10. Deleted activities during the partitioning of India. *The geography of all datasets is "IN" (India).*

Activity name	Time Period	Reference product
electricity production, hard coal	1980 - 2015	electricity, high voltage
electricity production, hydro, pumped storage	1945 - 2015	electricity, high voltage
electricity production, hydro, reservoir, alpine region	1945 - 2015	electricity, high voltage
electricity production, hydro, run-of-river	1945 - 2015	electricity, high voltage
electricity production, lignite	1980 - 2015	electricity, high voltage
electricity production, natural gas, combined cycle power plant	2000 - 2015	electricity, high voltage
electricity production, natural gas, conventional power plant	1990 - 2015	electricity, high voltage
electricity production, nuclear, boiling water reactor	1990 - 2015	electricity, high voltage
electricity production, nuclear, pressure water reactor, heavy water moderated	2010 - 2015	electricity, high voltage
electricity production, oil	1980 - 2015	electricity, high voltage
electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted	2005 - 2015	electricity, low voltage
electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted	2005 - 2015	electricity, low voltage
electricity production, wind, <1MW turbine, onshore	2000 - 2015	electricity, high voltage
electricity production, wind, >3MW turbine, onshore	2012 - 2012	electricity, high voltage
electricity production, wind, 1-3MW turbine, onshore	2005 - 2015	electricity, high voltage
electricity voltage transformation from high to medium voltage	2012 - 2012	electricity, medium voltage
electricity voltage transformation from medium to low voltage	2012 - 2012	electricity, low voltage
electricity, from municipal waste incineration to generic market for electricity, medium voltage	2012 - 2015	electricity, medium voltage
electricity, high voltage, import from BT	2012 - 2012	electricity, high voltage
heat and power co-generation, biogas, gas engine	2007 - 2015	electricity, high voltage
heat and power co-generation, wood chips, 6667 kW	2010 - 2015	heat, district or industrial, other than natural gas
market for electricity, high voltage	2012 - 2015	electricity, high voltage
market for electricity, low voltage	2012 - 2015	electricity, low voltage
market for electricity, medium voltage	2012 - 2015	electricity, medium voltage
treatment of coal gas, in power plant	1990 - 2015	coal gas

Table 11 reports all activities introduced during the project. To know more about the process of partitioning India, please consult the dedicated report Hossain, 2017, which can be downloaded from the ecoinvent webpage by any user (after identification on ecoQuery).

Table 11. New activities added for the partitioning of India, including markets.

Activity name	Geography	Time period
electricity production, deep geothermal	IN-TN	2015 - 2015
electricity production, hard coal	IN-AP; IN-BR; IN-CT; IN-DL; IN-GJ; IN-HR; IN-JH; IN-KA; IN-MH; IN-MP; IN-OR; IN-PB; IN-RJ; IN-TN; IN-UP; IN-WB	1980 - 2015
electricity production, hydro, pumped storage	IN-AP; IN-BR; IN-GJ; IN-MH; IN-TN; IN-WB	1945 - 2015
electricity production, hydro, reservoir, alpine region	IN-AP; IN-AS; IN-BR; IN-CT; IN-GJ; IN-HP; IN-JH; IN-KA; IN-KL; IN-MH; IN-ML; IN-MN; IN-MP; IN-NL; IN-OR; IN-PB; IN-RJ; IN-TN; IN-UP; IN-UT	1945 - 2015
electricity production, hydro, run-of-river	IN-AP; IN-AR; IN-AS; IN-GJ; IN-HP; IN-JK; IN-KA; IN-KL; IN-MH; IN-ML; IN-MP; IN-PB; IN-RJ; IN-SK; IN-TN; IN-UP; IN-UT; IN-WB	1945 - 2015
electricity production, lignite	IN-GJ; IN-RJ; IN-TN	1980 - 2015
electricity production, natural gas, combined cycle power plant	IN-AP; IN-AS; IN-DL; IN-GA; IN-GJ; IN-HR; IN-KL; IN-MH; IN-PY; IN-RJ; IN-TN; IN-TR; IN-UP	2000 - 2015
electricity production, natural gas, conventional power plant	IN-AP; IN-AS; IN-DL; IN-GA; IN-GJ; IN-HR; IN-KL; IN-MH; IN-PY; IN-RJ; IN-TN; IN-TR; IN-UP	1990 - 2015
electricity production, nuclear, boiling water reactor	IN-MH	1990 - 2015
electricity production, nuclear, pressure water reactor	IN-TN	1990 - 2015
electricity production, nuclear, pressure water reactor, heavy water moderated	IN-GJ; IN-KA; IN-MH; IN-RJ; IN-TN; IN-UP	2010 - 2015
electricity production, oil	IN-KA; IN-KL; IN-TN	1980 - 2015
electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted	IN-AP; IN-AR; IN-CT; IN-DL; IN-GJ; IN-HR; IN-JH; IN-KA; IN-KL; IN-MH; IN-MP; IN-OR; IN-PB; IN-PY; IN-RJ; IN-TN; IN-UP; IN-UT; IN-WB	2005 - 2015
electricity production, wind, 1-3MW turbine, onshore	IN-AP; IN-GJ; IN-KA; IN-KL; IN-MH; IN-MP; IN-RJ; IN-TN	2005 - 2015
electricity voltage transformation from high to medium voltage	IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid	2012 - 2012
electricity voltage transformation from medium to low voltage	IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid	2012 - 2012
electricity, high voltage, import from BT	IN-Eastern grid	2012 - 2015
electricity, high voltage, import from IN-Eastern grid	IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid	2012 - 2015
electricity, high voltage, import from IN-North-eastern grid	IN-Eastern grid; IN-Northern grid	2012 - 2015
electricity, high voltage, import from IN-Northern grid	IN-Eastern grid; IN-North-eastern grid; IN-Southern grid; IN-Western grid	2012 - 2015
electricity, high voltage, import from IN-Southern grid	IN-North-eastern grid; IN-Northern grid; IN-Western grid	2012 - 2015
electricity, high voltage, import from IN-Western grid	IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid	2012 - 2015
market for electricity, high voltage	IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid	2014 - 2017
market for electricity, low voltage	IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid	2014 - 2017

Activity name	Geography	Time period
market for electricity, medium voltage	IN-Eastern grid; IN-North-eastern grid; IN-Northern grid; IN-Southern grid; IN-Western grid	2014 - 2017
market group for electricity, high voltage	IN	2015 - 2015
market group for electricity, low voltage	IN	2015 - 2015
market group for electricity, medium voltage	IN	2015 - 2015

Please note that in the context of the update of the electricity markets (read chapter 3), specifically for the correct functioning of the consequential system model ("substitution, consequential, long-term"), two activities were added (Table 12).

Table 12. New activities added for the update of the consequential electricity markets.

Activity name	Geography	Time period
electricity production, wind, >3MW turbine, onshore	IN-TN	2016 - 2018
heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014	IN-TN	2010 - 2015

4.1 Asian aluminium industry electricity mix

As a consequence of the update, the two activities: "electricity production, coal, aluminium industry, IAI Area, Asia, without China and GCC, 2012 – 2012" and "electricity production, hydro, aluminium industry, IAI Area, Asia, without China and GCC, 2012 – 2012" had to have the links to Indian electricity producers redirected. This has affected the scores of those activities.

5 Chemical Products

Version 3.4 includes a significant extension of the coverage of chemical products. Selected existing datasets were reviewed and updated, and new datasets were created. Additionally, the ISIC codes of all the chemical activities that were updated were reviewed and changed in cases where the ISIC code from v3.3 was considered inaccurate.

Table 13 shows the list of transforming activities of existing chemical products for which the ISIC code was changed. The ISIC codes of the corresponding market activities were changed accordingly.

Table 13. List of transforming activities, and their corresponding markets, for which the ISIC code was changed. *The ISIC codes in v3.3 and v3.4 are shown.*

Activity name	Geography	ISIC code in v3.3	ISIC code in v3.4
activated bentonite production	GLO; DE	0810:Quarrying of stone, sand and clay	2011:Manufacture of basic chemicals
alkylbenzene production, linear	GLO; RER; CA-QC	2011:Manufacture of basic chemicals	2023:Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
market for activated bentonite	GLO	0810:Quarrying of stone, sand and clay	2011:Manufacture of basic chemicals
market for alkylbenzene, linear	GLO	2011:Manufacture of basic chemicals	2023:Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
market for naphthalene sulfonic acid	GLO	2011:Manufacture of basic chemicals	2029:Manufacture of other chemical products n.e.c.
market for titanium dioxide	GLO; RER	0729:Mining of other non-ferrous metal ores	2011:Manufacture of basic chemicals
naphthalene sulfonic acid production	GLO; RER	2011:Manufacture of basic chemicals	2029:Manufacture of other chemical products n.e.c.
styrene production	GLO; RER	2013:Manufacture of plastics and synthetic rubber in primary forms	2011:Manufacture of basic chemicals
titanium dioxide production, chloride process	GLO; RER	0729:Mining of other non-ferrous metal ores	2011:Manufacture of basic chemicals
titanium dioxide production, sulfate process	GLO; RER	0729:Mining of other non-ferrous metal ores	2011:Manufacture of basic chemicals

The datasets for steam production in the chemical industry were also reviewed under the scope of this project. These datasets are described in more detail in chapter 5.3.

5.1 New chemical products

The update and creation of datasets is based as much as possible in industry data. When confidentiality issues arose, extensive literature research was conducted to identify bill of materials, production routes and energy requirements. Complementary, a model developed internally by ecoinvent was used at a flow-specific level.

The model can cover emissions of reactants and reagents to air and water, including treatment and waste stream processing. The development of this part of the model was in parts based on the following publications: Hischier, et al., 2005 and Wernet, et al., 2012. In addition, the model also covers energy, cooling and process water as well as general reagents and supporting machinery and infrastructure. This information relies on average industry data. More information on the model can be found in Wernet et al. ,2017.

Table 14 below lists the new chemical products, while Table 15 reports the newly added markets.

Table 14. List of new transforming activities for chemical products. *All activities have the time period 2015-2020.*

Activity name	Geography	Reference Product
2,4-dinitrotoluene production	GLO	2,4-dinitrotoluene
2,4-di-tert-butylphenol production	GLO	2,4-di-tert-butylphenol
2,5-dimethylhexane-2,5-dihydroperoxide production	GLO	2,5-dimethylhexane-2,5-dihydroperoxide
2,6-di-tert-butylphenol production	GLO	2,6-di-tert-butylphenol
acetone production, from isopropanol	GLO; RER	acetone, liquid
alkyl sulphate (C12-14) production	GLO	alkyl sulphate (C12-14)
aluminium chloride production	GLO	aluminium chloride
amine oxide production	GLO; RER	amine oxide
ascorbic acid production	GLO; RER	ascorbic acid
azodicarbonamide production	GLO; RER	azodicarbonamide
barium carbonate production	GLO	barium carbonate
barium hydroxide production	GLO	barium hydroxide
barium oxide production	GLO	barium oxide
barium sulfide production	GLO	barium sulfide
benzaldehyde-2-sulfonic acid production	GLO	benzaldehyde-2-sulfonic acid
butyldiglycol acetate production	GLO	butyldiglycol acetate
calcium carbonate production, precipitated	GLO; RER	calcium carbonate, precipitated
cocamide diethanolamine production	GLO; RER	cocamide diethanolamine
decabromodiphenyl ether production	GLO; RER	decabromodiphenyl ether
dimethyl carbonate production	GLO; RER	dimethyl carbonate
dimethyl hexanediol production	GLO	dimethyl hexanediol
dimethyl hexynediol production	GLO	dimethyl hexynediol
dimethylaminopropylamine production	GLO; RER	dimethylaminopropylamine
dimethyldichlorosilane production	GLO	dimethyldichlorosilane
dinitrogen tetroxide production	GLO	dinitrogen tetroxide

Activity name	Geography	Reference Product
dodecanol production, from coconut oil	GLO	dodecanol
dodecanol production, ziegler process	GLO	dodecanol
enzymes production	GLO; RER	enzymes
ethoxylated alcohol (AE>20) production, palm oil	GLO; RER	ethoxylated alcohol (AE>20)
fatty acid production, from coconut oil	GLO; RER	fatty acid
glucose production	GLO; RER	glucose
hydrazine sulfate production	GLO	hydrazine sulfate
morpholine production	GLO	morpholine
nitric oxide production	GLO	nitric oxide
non-ionic surfactant production, ethylene oxide derivate	GLO	non-ionic surfactant
non-ionic surfactant production, fatty acid derivate	GLO	non-ionic surfactant
octabenzone production	GLO	octabenzone
phenol production, from cumene	GLO; RER	phenol
phosphorus oxychloride production	GLO	phosphorus oxychloride
phosphorus trichloride production	GLO	phosphorus trichloride
polyaluminium chloride production	GLO	polyaluminium chloride
polydimethylsiloxane production	GLO	polydimethylsiloxane
salicylic acid production	GLO	salicylic acid
sodium chloroacetate production	GLO	sodium chloroacetate
sodium cumenesulphonate production	GLO; RER	sodium cumenesulphonate
sodium hydrogen sulfate production	GLO	sodium hydrogen sulfate
sodium oxide production	GLO; RER	sodium oxide
stearic acid production	GLO	stearic acid
styrene production*	GLO; RER	styrene
succinic acid production	GLO	succinic acid
sulfamic acid production	GLO	sulfamic acid
triphenyl phosphate production	GLO	triphenyl phosphate
tris(2,4-ditert-butylphenyl) phosphite production	GLO	tris(2,4-ditert-butylphenyl) phosphite
trisodium phosphate production	GLO	trisodium phosphate

** This dataset was present solely as aggregated LCI in previous versions of ecoinvent. It has been fully remodelled.*

Table 15. List of new market activities for chemical products. *All activities have the time period 2015-2020.*

Activity name	Geography	Reference Product
market for 2,4-dinitrotoluene	GLO	2,4-dinitrotoluene
market for 2,4-di-tert-butylphenol	GLO	2,4-di-tert-butylphenol
market for 2,5-dimethylhexane-2,5-dihydroperoxide	GLO	2,5-dimethylhexane-2,5-dihydroperoxide
market for 2,6-di-tert-butylphenol	GLO	2,6-di-tert-butylphenol
market for alkyl sulphate (C12-14)	GLO	alkyl sulphate (C12-14)
market for aluminium chloride	GLO	aluminium chloride
market for amine oxide	GLO	amine oxide

Activity name	Geography	Reference Product
market for ascorbic acid	GLO	ascorbic acid
market for azodicarbonamide	GLO	azodicarbonamide
market for barium carbonate	GLO	barium carbonate
market for barium hydroxide	GLO	barium hydroxide
market for barium oxide	GLO	barium oxide
market for barium sulfide	GLO	barium sulfide
market for benzaldehyde-2-sulfonic acid	GLO	benzaldehyde-2-sulfonic acid
market for butyldiglycol acetate	GLO	butyldiglycol acetate
market for calcium carbonate, precipitated	GLO	calcium carbonate, precipitated
market for cocamide diethanolamine	GLO	cocamide diethanolamine
market for decabromodiphenyl ether	GLO	decabromodiphenyl ether
market for dimethyl carbonate	GLO	dimethyl carbonate
market for dimethyl hexanediol	GLO	dimethyl hexanediol
market for dimethyl hexynediol	GLO	dimethyl hexynediol
market for dimethylaminopropylamine	GLO	dimethylaminopropylamine
market for dimethyldichlorosilane	GLO	dimethyldichlorosilane
market for dinitrogen tetroxide	GLO	dinitrogen tetroxide
market for dodecanol	GLO	dodecanol
market for enzymes	GLO	enzymes
market for ethoxylated alcohol (AE>20)	GLO	ethoxylated alcohol (AE>20)
market for glucose	GLO	glucose
market for hydrazine sulfate	GLO	hydrazine sulfate
market for methylpyrrolidone	GLO	methylpyrrolidone
market for morpholine	GLO	morpholine
market for nitric oxide	GLO	nitric oxide
market for non-ionic surfactant	GLO	non-ionic surfactant
market for octabenzone	GLO	octabenzone
market for phosphorus oxychloride	GLO	phosphorus oxychloride
market for phosphorus trichloride	GLO	phosphorus trichloride
market for polyaluminium chloride	GLO	polyaluminium chloride
market for polydimethylsiloxane	GLO	polydimethylsiloxane
market for salicylic acid	GLO	salicylic acid
market for sodium chloroacetate	GLO	sodium chloroacetate
market for sodium cumenesulphonate	GLO	sodium cumenesulphonate
market for sodium hydrogen sulfate	GLO	sodium hydrogen sulfate
market for sodium oxide	GLO	sodium oxide
market for stearic acid	GLO	stearic acid
market for succinic acid	GLO	succinic acid
market for sulfamic acid	GLO	sulfamic acid
market for triphenyl phosphate	GLO	triphenyl phosphate
market for tris(2,4-ditert-butylphenyl) phosphite	GLO	tris(2,4-ditert-butylphenyl) phosphite
market for trisodium phosphate	GLO	trisodium phosphate

The activities “fatty acid production, from vegetable oil, RER” and “fatty acid production, from vegetable oil, GLO” have been split into four different activities according to the feedstock used (see Table 16). In v3.3, “fatty acid production, from vegetable oil” GLO and RER considered as an input an equal share of the four different oils coconut, palm kernel, palm, and soybean. With the creation of new activities, a production volume had to be assigned to each of them. As all datasets have the same Reference Product “fatty acid”, the share of oils contributing to the “market for fatty acid, GLO” changed. This means that the user might experience changes in LCIA results.

Table 16. List of activities replacing the activities “fatty acid production, from vegetable oil” GLO and RER. *All activities have the same Reference Product “fatty acid”. The activities RER and GLO “fatty acid production, from vegetable oil” have been deleted.*

Activity name	Geography	Time period
fatty acid production, from coconut oil	GLO; RER	2005-2020
fatty acid production, from palm kernel oil	GLO; RER	1995-1995
fatty acid production, from palm oil	GLO; RER	1995-1995
fatty acid production, from soybean oil	GLO; RER	1995-1995

5.2 Updated chemical products

115 transforming activities for chemical products (including paints, detergents and refined petroleum products) that already existed in v3.3 were reviewed and updated. The updates include new exchange amounts, production volumes, prices and improvements of the documentation. Table 17 shows the list of existing transforming activities that were reviewed, and the types of changes that were made. If the changes were extensive enough to warrant an update of the time period, it was updated as well.

Table 17. List of updated transforming activities for chemical products (including paints, detergents and refined petroleum products). *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 v3.4, "U" stands for "Updated", "D" means that only the documentation was improved, as either no new data could be found, or the data was considered to be representative of the current production process. *Geography was changed from WEU to RER.*

Activity name	Geography	Time period	V3.4
1-propanol production	GLO; RER	1998 - 2006	U
acetaldehyde production	GLO; RER	1995 - 2020	U
acetic acid production, product in 98% solution state	GLO; RER	1997 - 2020	U
acetylene production	GLO; CH	1991 - 2020	U
acrylic acid production	GLO; RER	2000 - 2020	U
acrylic binder production, product in 34% solution state	GLO; RER	1995 - 1995	U
acrylic dispersion production, product in 65% solution state	GLO; RER	1996 - 1996	D
acrylic filler production	GLO; RER	2000 - 2003	D
activated bentonite production	GLO; DE	1997 - 2000	U
activated silica production	GLO	2012 - 2020	U
adipic acid production	GLO; RER	1997 - 2020	U
air separation, cryogenic	GLO; CA-QC	1997 - 2001	U
air separation, cryogenic	RER	1997 - 2001	D
alkyd paint production, white, solvent-based, product in 60% solution state	GLO; RER	1995 - 2020	U
alkyd paint production, white, water-based, product in 60% solution state	GLO; RER	1995 - 2020	U
alkylbenzene production, linear	GLO; RER; CA-QC	1995 - 2020	U
alkylbenzene sulfonate production, linear, petrochemical	GLO; RER	1992 - 1995	U
aluminium sulfate production, powder	GLO; RER	1995 - 2000	U
aniline production	GLO; RER	2000 - 2020	U
argon production, liquid	GLO; RER	1997 - 2001	U
benzyl alcohol production	GLO; RER	1998 - 2006	U
bisphenol A production, powder	GLO; RER	2000 - 2020	U
butyl acetate production	GLO; RER	1991 - 2020	U
butyl acrylate production	GLO; RER	1995 - 1995	U
cadmium sulfide production, semiconductor-grade	GLO; US	1981 - 1999	D
cadmium telluride production, semiconductor-grade	GLO; US	1985 - 2005	D
carbon black production	GLO	2000 - 2020	U
carbon dioxide production, liquid	GLO; RER	1979 - 2020	U
chlor-alkali electrolysis, diaphragm cell	GLO; RER	2000 - 2000	U
chlor-alkali electrolysis, membrane cell	GLO; RER; CA-QC	2000 - 2000	U
chlor-alkali electrolysis, mercury cell	GLO; RER	2000 - 2000	U
chlorine dioxide production	GLO; RER	2000 - 2020	U
chromium oxide production, flakes	GLO; RER	2000 - 2020	U
compressed air production, 1000 kPa gauge, <30kW, optimised generation	GLO; RER	2003 - 2015	U
compressed air production, 1200 kPa gauge, <30kW, optimized generation	GLO; RER	2003 - 2015	U

Activity name	Geography	Time period	V3.4
compressed air production, 700 kPa gauge, >30kW, best generation	GLO; RER	2005 - 2015	U
copper oxide production	GLO; RER	2000 - 2020	U
cyclohexane production	GLO; RER	1975 - 2006	U
cyclohexanone production	GLO; RER	1991 - 2020	U
dimethylacetamide production	GLO	2000 - 2020	U
dimethylamine production	GLO; RER	2000 - 2020	U
dipropylene glycol monomethyl ether production	GLO; RER	2000 - 2020	U
EDTA production	GLO; RER	2000 - 2020	U
electrolysis of lithium chloride	GLO	2006 - 2006	U
ethanolamine production	GLO; RER	2000 - 2020	U
ethoxylated alcohol (AE11) production, palm oil	GLO; RER	1992 - 1995	U
ethoxylated alcohol (AE3) production, coconut oil	GLO; RER	1992 - 1995	U
ethoxylated alcohol (AE3) production, palm kernel oil	GLO; RER	1992 - 1995	U
ethoxylated alcohol (AE3) production, petrochemical	GLO; RER	1992 - 1995	U
ethoxylated alcohol (AE7) production, coconut oil	GLO; RER	1992 - 1995	U
ethoxylated alcohol (AE7) production, palm kernel oil	GLO; RER	1992 - 1995	U
ethoxylated alcohol (AE7) production, petrochemical	GLO; RER	1992 - 2020	U
ethyl acetate production	GLO; RER	1991 - 2020	U
ethylene carbonate production	GLO; CN	2009 - 2010	U
ethylene hydration	GLO; RER	1986 - 2005	U
ethylenediamine production	GLO; RER	2000 - 2020	U
fluorination of sodium tetrahydridoborate	GLO	2000 - 2020	U
flux production, for wave soldering	GLO	2005 - 2020	U
formic acid production, methyl formate route	GLO; RER	1984 - 2006	U
hydrochloric acid production, from the reaction of hydrogen with chlorine	GLO; RER; CA-QC	1997 - 2020	U
hydroformylation of propylene	GLO; RER	1989 - 2005	U
hydrogen fluoride production	GLO	1979 - 2020	U
hydrogen peroxide production, product in 50% solution state	GLO; RER	1995 - 1995	U
hydrogen sulfide production	GLO; RER	2005 - 2015	U
hydroxylamine production	GLO; RER	2010 - 2020	U
isopropanol production	GLO; RER	2000 - 2020	U
lithium carbonate production, from concentrated brine	GLO	2009 - 2010	U
lithium hydroxide production	GLO	2000 - 2020	U
lubricating oil production	GLO; RER	2000 - 2020	U
magnetite production	GLO	1994 - 1996	D
maleic anhydride production by catalytic oxidation of benzene	GLO; RER	1997 - 2020	U
maleic anhydride production by direct oxidation of n-butane	GLO; RER	1997 - 2020	U
manganese dioxide production	GLO	2000 - 2020	U
manganese sulfate production	GLO	2005 - 2020	U
mannheim process	GLO	2000 - 2000	U
mannheim process	RER	2000 - 2000	U
melamine production	GLO; RER	2000 - 2020	U

Activity name	Geography	Time period	V3.4
methanol production	GLO	1994 - 2001	D
methyl ethyl ketone production	GLO; RER	2000 - 2020	U
naphthalene sulfonic acid production	GLO; RER	2010 - 2020	U
nickel sulfate production	GLO	2006 - 2020	U
oxidation of manganese dioxide	GLO; RER	1990 - 2020	U
oxidation of methanol	GLO; RER	1997 - 2020	U
ozone production, liquid	GLO; RER	2000 - 2020	U
pentaerythritol production in sodium hydroxide solution	GLO; RER	1997 - 2020	U
phenol production	GLO; RER	2000 - 2020	U
phosphoryl chloride production	GLO; RER	2000 - 2020	U
potassium carbonate production, from potassium hydroxide	GLO	2000 - 2020	U
potassium hydroxide production	GLO; RER	1998 - 2004	U
purification of wet-process phosphoric acid to industrial grade, product in 85% solution state	GLO; RER	1990 - 1994	U
refrigerant R134a production	GLO; RER	1999 - 2000	U
selenium production	GLO; RER	2000 - 2020	U
silicon hydrochloration	GLO	2000 - 2007	U
silicon production, electronics grade	DE	1992 - 2005	U
silicon production, electronics grade	GLO	1992 - 2005	D
silicon production, metallurgical grade	GLO; NO	2000 - 2002	U
silicon production, multi-Si, casted	GLO; RER; CA-QC	1997 - 2005	D
silicon production, single crystal, Czochralski process, photovoltaics	GLO; RER	1992 - 2006	U
silicon production, solar grade, modified Siemens process	GLO; RER	2004 - 2005	D
soap production	GLO; RER	1992 - 2020	U
soda production, solvay process	GLO; RER	1999 - 1999	U
sodium chlorate production, powder	GLO; RER; CA-QC	1990 - 1995	U
sodium dichromate production	GLO; RER	1997 - 2000	U
sodium dithionite production, anhydrous	GLO; RER	2000 - 2020	U
sodium formate production	GLO	1950 - 2020	U
sodium hydrogen sulfite production	GLO; RER	2010 - 2020	U
sodium hypochlorite production, product in 15% solution state	GLO; RER; CA-QC	1997 - 2000	U
sodium nitrate production	GLO; RER	2010 - 2020	U
sodium persulfate production	GLO	2000 - 2020	U
sodium phosphate production	GLO; RER	1994 - 2020	U
sodium pyrophosphate production	GLO	2012 - 2020	U
sodium silicate production, spray powder, 80%	GLO; RER	1995 - 1995	U
sodium sulfate production, from natural sources	GLO; RER	2000 - 2000	D
sodium sulfite production	GLO; RER	2010 - 2020	U
sodium tripolyphosphate production	GLO; RER	1986 - 1994	U
sulfur dioxide production, liquid	GLO; RER	1997 - 2020	U
sulfuric acid production	GLO; RER	2001 - 2001	D
titanium dioxide production, chloride process	GLO; RER	2005 - 2005	D

Activity name	Geography	Time period	V3.4
titanium dioxide production, sulfate process	GLO; RER	2005 - 2005	D
toluene oxidation	GLO; RER	2010 - 2020	U
trichloroethylene production	GLO; RER*	2015 - 2020	U
trimethyl borate production	GLO	2000 - 2020	U
white spirit production	GLO; RER	2000 - 2020	U
zinc monosulfate production	GLO; RER	2005 - 2007	U
zinc oxide production	GLO; RER	2005 - 2020	U
zinc sulfide production	GLO; RER	2005 - 2020	U
ammonia production, partial oxidation, liquid	GLO; RER	2000 - 2000	D
ammonia production, steam reforming, liquid	GLO; RER	2000 - 2000	D
ammonium bicarbonate production	GLO; RER	1995 - 1995	U
benzimidazole-compound production	GLO; RER	2000 - 2010	U
benzo[thia]diazole-compound production	GLO; RER	2000 - 2010	U
folpet production	GLO; RER	2000 - 2020	U
nitric acid production, product in 50% solution state	GLO; RER	1990 - 2020	U
nitrile-compound production	GLO; RER	2000 - 2020	U
phosphane production	GLO	2000 - 2020	U
potassium sulfate production	GLO; RER	1999 - 1999	U

In the context of the review and update of transforming activities for chemical products, the transforming activity “water production, deionised, from tap water, at user” with the geographies “GLO”, “Europe without Switzerland” and “CH” was reviewed. As the data was considered to be up to date, only the documentation was reviewed and extended based on literature.

5.3 Energy and steam production in chemical industry

In the context of the review and update of transforming activities for chemical products, the transforming activities for steam production, named in v3.3 “steam production in chemical industry” (with the reference product “heat, in chemical industry”, expressed in MJ) and “steam production, in chemical industry” (with the reference product “steam, in chemical industry”, expressed in kg) were updated for the both geographies GLO and RER.

The activity “steam production, in chemical industry” was originally created based on data concerning steam production collected from 11 European plants that produce sodium silicates or percarbonate (Zah and Hischier, 2007). The activity “steam production in chemical industry” was created separately, and is based on data collected from 215 steam plants used in the European chemical and petrochemical industry (Althaus et al., 2007). Since both activities were created independently from each other, the energy and water use were different.

In an effort to harmonize these two datasets, the consumption of energy and water is now modelled only in the activity “steam production in chemical industry”, and this activity was renamed “steam production, as energy carrier, in chemical industry”; and its reference product to “heat, from

steam, in chemical industry" to make it more explicit that the reference product is expressed in terms of energy (with the unit "MJ").

The activity "steam production, in chemical industry" continues to produce "steam, in chemical industry". It bears no inputs of energy and water, but only one input of 2.75 MJ of "heat, from steam, in chemical industry", which corresponds to the energy content of 1 kg of steam (Althaus et al., 2007). This way, if users add an input 1 kg of "steam, in chemical industry" or 2.75 of "heat, from steam, in chemical industry", the energy and water consumption will be the same in both cases.

6 European natural gas supply chains

6.1 Natural gas production and processing

Natural gas production in Norway, Russia and the Netherlands and liquefied natural gas (LNG) production in Algeria, which represent the mayor supplier to the European market, were updated with the latest available data. In particular, data for losses and emissions related to flaring, venting and fugitive emissions were improved.

For geographies where the sour nature of the gas requires sweetening, the recovery of elemental sulfur from the sweetening process has so far been neglected and is now introduced as by-product. To do this in a consistent manner across all geographies the by-product was added to natural gas production datasets, rather than the sweetening datasets, regardless of whether sweetening is modelled separately or not. A separate activity "sweetening, natural gas" exist for the geographies Germany and Global. New information is not comprehensively available for this activity. Punctual updates were made for the venting of gas, as well as the production volumes

Moreover, the production volumes of all natural gas producing activities were updated to 2012 figures and minor corrections of exchange amounts were made to the US natural gas production.

Table 18. New and updated activities related to natural gas production. *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 v3.4, "N" stands for "New", "U" stands for "Updated".*

Activity Name	Geography	Time period	V3.4
natural gas production	CA-AB; US	2010 - 2010	U
natural gas production	DE	1996 - 2000	U
natural gas production	DZ; GLO	1989 - 2000	U
natural gas production	RU	2000 - 2012	U
petroleum and gas production, off-shore	GB	1998 - 2000	U
petroleum and gas production, off-shore	GLO; NL; NO	2000 - 2000	U
petroleum and gas production, on-shore	CA-AB; NG; US	1999 - 2000	U
petroleum and gas production, on-shore	GLO; NL	2000 - 2012	U
natural gas production, liquefied	DZ; GLO	2012 - 2012	U
natural gas production, liquefied	RME	2012 - 2012	N
sweetening, natural gas	DE; GLO	1996 - 2000	U

6.2 Natural gas transport

The main impact related to the transmission of natural gas via pipelines stems from gas leakages. Leakage rates and respective emissions were therefore updated for natural gas transport in high pressure, long distance pipelines, both on-shore and off-shore.

Activities related to the transport of liquefied natural gas (LNG) include liquefaction (see chapter 6.1), sea transport by LNG carrier and subsequent regasification (evaporation). Data for energy use, combustion rates and fugitive emissions of these processes were updated, as well as the production volume for natural gas evaporation in Europe and globally.

Table 19. Updated activities related to natural gas transport. *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column. *The geography "RER w/o DE+NL+NO+RU" replaces the geography "RER w/o DE+NL+NO".*

Activity name	Geography	Time period	Reference Product
evaporation of natural gas	GLO; RER	2001 - 2001	natural gas, high pressure
transport, pipeline, long distance, natural gas	DE; NL; RER w/o DE+NL+NO+RU*	2000 - 2012	transport, pipeline, long distance, natural gas
transport, pipeline, long distance, natural gas	GLO	1994 - 2000	transport, pipeline, long distance, natural gas
transport, pipeline, long distance, natural gas	RU	2001 - 2012	transport, pipeline, long distance, natural gas
transport, pipeline, offshore, long distance, natural gas	DZ; GLO; NO	2000 - 2012	transport, pipeline, offshore, long distance, natural gas
transport, pipeline, onshore, long distance, natural gas	DZ; GLO; NO	2000 - 2012	transport, pipeline, onshore, long distance, natural gas
transport, freight, sea, liquefied natural gas	GLO	2006 - 2006	transport, freight, sea, liquefied natural gas

In general, those activities have higher impacts now (GWP 100a, IPCC2013); among other reasons, the electricity used in the compressor has been linked to a compressor operated with natural gas, instead of being linked dot the local electricity market mix. This change in scores affects all activities subsequently using this transport.

6.3 Natural gas imports

Natural gas trade movements are modelled as following in the ecoinvent v3 database. The regional market (e.g. market for natural gas, high pressure, CH) imports high pressure natural gas according to the production volumes of the datasets "natural gas, high pressure, import from XX, CH", where XX here symbolises the country of the gas' origin. The production volumes correspond to the quantity imported from a gas producing country, both directly and in the form of re-exports of transit countries. The datasets "natural gas, high pressure, import from XX, CH" therefore have a fixed link to the natural gas producing activities.

To assure up-to-date supply mixes, the production volumes of the natural gas imports to European countries were updated based on the trade movements of the natural gas in 2012 as described in BP statistical review 2014 (Amoco 2014). For Switzerland calculations were based on the statistics of the Swiss association of the natural gas industry (VSG) for 2012 (Faist Emmenegger et al., 2017). In line with the statistics, some import activities existing in v3.3 were found outdated and therefore deleted.

Furthermore, assumptions on transport distances via on-shore and off-shore pipelines were revised for all import datasets and improved where found inaccurate. These changes affect the results of LCIA of all imports (by increasing or decreasing the scores). In the case of Algeria (DZ), the imports were structured until v3.3 around a fixed share of evaporated gas:pipeline gas; now those shares are country specific.

See the following tables for a summary of all activities modified.

Table 20. Updated activities related to natural gas imports. *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	Reference Product
natural gas, high pressure, import from DE	AT; CH	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from DZ	CH; ES; FR; IT	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from GB	CH	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from NL	BE; CH; DE; FR; IT	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from NO	AT; BE; CH; CZ; DE; DK; ES; FR; GB; NL; SE	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from RU	AT; CH; CZ; DE; FI; FR; GR; HU; IT; SK	2012 - 2012	natural gas, high pressure

Table 21. New activities related to natural gas imports. *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	Reference Product
natural gas, high pressure, import from DE	DK; PL	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from DZ	GB; GR; NL; PL	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from GB	BE; DK; IE; NL	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from NL	AT; DK; GB; PL;	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from NO	IT; PL	2012 - 2012	natural gas, high pressure
natural gas, high pressure, import from RU	BE; DK; ES; GB; NL; PL	2012 - 2012	natural gas, high pressure

Table 22. Deleted activities related to natural gas imports. *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	Reference Product
natural gas, high pressure, import from DE	HU; BE; IT	2000-2000	natural gas, high pressure
natural gas, high pressure, import from DZ	HU	2000-2000	natural gas, high pressure
natural gas, high pressure, import from NL	HU	2001-2001	natural gas, high pressure
natural gas, high pressure, import from NO	HU; IE	2001-2001	natural gas, high pressure

6.4 Natural gas markets

For the geographies of Algeria (DZ), Russia (RU) and Norway (NO) markets for natural gas, high pressure were introduced. Energy requirements and emissions of the high-pressure network were approximated based on other countries. Estimates for average transport distances within the regional markets were made using maps of natural gas pipelines, Google Earth and country specific sources, where available.

For updated markets, the transport distances have been improved, and losses adjusted.

Table 23. Updated and new activities related to natural gas markets. *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 v3.4, "N" stands for "New", "U" stands for "Updated".*

Activity Name	Geography	Time period	V3.4
market for natural gas, high pressure	AT	1997 - 2000	U
market for natural gas, high pressure	CH	2000 - 2000	U
market for natural gas, high pressure	DE	2000 - 2000	U
market for natural gas, high pressure	DZ	2012 - 2012	N
market for natural gas, high pressure	ES	2000 - 2000	U
market for natural gas, high pressure	FI	2000 - 2000	U
market for natural gas, high pressure	NL	1997 - 2000	U
market for natural gas, high pressure	NO	2012 - 2012	N
market for natural gas, high pressure	RU	2012 - 2012	N
market for natural gas, high pressure	SE	2000 - 2000	U
market for natural gas, high pressure	SK	2000 - 2000	U

6.5 Natural gas distribution in Switzerland

Between 1998 and 2012, several changes took place in the Swiss distribution network: the length of the pipelines for distribution in the Swiss network grew from around 14600 km to almost 19000 km. Furthermore, the cast iron pipelines were continuously replaced by polyethylene pipelines which have a lower methane leakage rate. These changes are taken up in a comprehensive update of the respective Swiss natural gas infrastructure and market datasets, as listed in Table 24.

Table 24. Updated activities related to Swiss natural gas distribution.

Activity name	Geography	Time period	Reference Product
market for natural gas, high pressure	CH	2000 - 2000	natural gas, high pressure
market for natural gas, low pressure	CH	2000 - 2000	natural gas, low pressure
pipeline construction, natural gas, high pressure distribution network	CH	2012 - 2012	pipeline, natural gas, high pressure distribution network
pipeline construction, natural gas, low pressure distribution network	CH	2012 - 2012	pipeline, natural gas, low pressure distribution network

6.6 Methane production

The activity “methane production, 96% by volume, from synthetic gas, wood”, that generated “methane, 96% by volume” has been split into two distinct technologies, fixed bed and fluidised, using new data. A summary can be seen in the following table.

Table 25. New data concerning methane production. *If several geographies of the same activity with the same time period exist, all of them are listed in the “Geography” column. The activities CH and GLO “methane production, 96% by volume, from synthetic gas, wood” have been deleted.*

Activity name	Geography	Time period	Reference Product
methane production, 96% by volume, from synthetic gas, wood, fixed bed technology	CH; GLO	2008 - 2016	methane, 96% by volume
methane production, 96% by volume, from synthetic gas, wood, fluidised technology	CH; GLO	2008 - 2016	methane, 96% by volume

7 Plastics and synthetic rubber in primary forms

In ecoinvent version 3.3, the activities “epoxy resin production, liquid” GLO and RER, and “methylene diphenyl diisocyanate production” GLO and RER are only available at the aggregate level. In the context of the expansion of the chemical product sector (described in chapter 5), the activities “epoxy resin production” GLO and RER, and “methylene diphenyldiisocyanate production” GLO and their respective global markets were introduced. These activities are available as UPRs, LCIs and LCIAs.

In addition, other transforming activities for plastics and synthetic rubber were updated. The list of all new and updated activities in v3.4 for plastics and synthetic rubber in primary form is presented in Table 26.

Table 26. List of new and updated activities for plastics and synthetic rubber in primary forms. *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 v3.4, “N” stands for “New”, “U” stands for “Updated”, “D” means that only the documentation was improved, as either no new data could be found, or the data was considered to be representative of the current production process.*

Activity name	Geography	Time period	V3.4
anionic resin production	GLO; CH	1997 - 2020	U
cationic resin production	GLO; CH	1997 - 2020	U
epoxy resin production	GLO; RER	2015 - 2020	N
market for epoxy resin	GLO	2015 - 2020	N
melamine formaldehyde resin production	GLO; RER	1995 - 1995	D
methylene diphenyldiisocyanate production	GLO	2015 - 2020	N
market for methylene diphenyldiisocyanate	GLO	2015 - 2020	N
phenolic resin production	GLO; RER	2000 - 2020	U
polyurethane production, flexible foam	GLO; RER	1997 - 2020	U
tetrafluoroethylene production	GLO; RER	1999 - 2020	U
urea formaldehyde resin production	GLO; RER	1995 - 2020	U

8 Recycling of post-consumer PE and PET packaging material

The release of v3.4 includes new inventories for the sorting and recycling of post-consumer polyethylene (PE) and polyethylene terephthalate (PET) packaging materials into secondary granulates. In addition, an alternative recovery option for PE is offered by the conversion of sorted PE into light fuel oil through the process of thermal depolymerisation. These new datasets broaden the range of waste fractions and recycling activities covered by the database. The data collection and LCI modelling that serves as the basis for this data submission to ecoinvent is described in a technical report by Kägi et al., 2017, and any deviations from this source have been accounted for directly in the datasets.

Table 27. New activities for the recycling chains of post-consumer PE and PET waste packaging. *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 "Time period", the entry "2010-2014" indicates that the respective reference years for CH (2014) and for Europe without Switzerland and the US (2010) have been combined to define the time period for the GLO activity.*

Activity Name	Geography	Time period
container production, for collection of post-consumer waste plastic for recycling	CH; Europe without Switzerland; GLO; US	2010 - 2010
light fuel oil production, from waste polyethylene	CH; GLO	2010 - 2010
market for container, for collection of post-consumer waste plastic for recycling	CH; Europe without Switzerland; GLO; US	2010 - 2010
market for polyethylene terephthalate, granulate, amorphous, recycled	CH; Europe without Switzerland; GLO; US	2010 - 2014
market for polyethylene terephthalate, granulate, bottle grade, recycled	CH; GLO	2014 - 2014
market for polyethylene, high density, granulate, recycled	CH; Europe without Switzerland; GLO; US	2010 - 2014
market for waste polyethylene terephthalate, for recycling, sorted	CH; Europe without Switzerland; GLO; US	2010 - 2014
market for waste polyethylene terephthalate, for recycling, unsorted	CH; Europe without Switzerland; GLO; US	2010 - 2014
market for waste polyethylene, for recycling, sorted	CH; Europe without Switzerland; GLO; US	2010 - 2014
market for waste polyethylene, for recycling, unsorted	CH; Europe without Switzerland; GLO; US	2010 - 2014
market for waste preparation facility	GLO	2000 - 2014
polyethylene production, high density, granulate, recycled	CH; Europe without Switzerland; GLO; US	2010 - 2014
polyethylene terephthalate production, granulate, amorphous, recycled	CH; Europe without Switzerland; GLO; US	2010 - 2014
polyethylene terephthalate production, granulate, bottle grade, recycled	CH; GLO	2014 - 2014
polyethylene terephthalate, granulate, amorphous, recycled to generic market for amorphous PET granulate	CH; Europe without Switzerland; GLO; US	2010 - 2014
polyethylene terephthalate, granulate, bottle grade, recycled to generic market for bottle grade PET granulate	CH; GLO	2014 - 2014
polyethylene, high density, granulate, recycled to generic market for high density PE granulate	CH; Europe without Switzerland; GLO; US	2010 - 2014
treatment of waste polyethylene terephthalate, for recycling, unsorted, sorting	CH; Europe without Switzerland; GLO; US	2010 - 2014
treatment of waste polyethylene, for recycling, unsorted, sorting	CH; Europe without Switzerland; GLO; US	2010 - 2014
waste preparation facility construction	CH; GLO	2000 - 2014

Recycled PE and PET granulates are linked to the generic markets for these products via renaming activities. Recycled material is assumed to represent negligible share a of overall global market for plastic granulates (for example, WEF 2016 states the total share of closed-loop recycling for plastic packaging material to about 2% in 2013). The annual production volumes of these renaming activities were hence assigned sufficiently low amounts to establish the link to the respective market activities for the generic products (listed in Table 28) while ensuring only minor contributions to these product systems in all system models.

Table 28. Products affected by the changes described in Table 27.

Product name
light fuel oil
polyethylene, high density, granulate
polyethylene terephthalate, granulate, amorphous
polyethylene terephthalate, granulate, bottle grade

In order to reflect the limited supply of sorted waste material for recycling, and subsequently the recycled PE and PET granulates in the linking of the consequential System Model, the corresponding market activities were modelled as constrained (as indicated in the rightmost column in Table 29). Marginal consuming activities were defined as the production of the recycled granulates (in the cases of sorted waste material for recycling) and the renaming activities to generic markets (for the recycled PE and PET granulates), respectively.

Table 29. New markets (and new products) related to recycling chains of post-consumer PE and PET waste packaging. *When a market is constrained, it is signaled by "C" in the column "Market".*

Activity Name	Geography	Time period	Market
market for container, for collection of post-consumer waste plastic for recycling	CH; Europe without Switzerland; GLO; US	2010 - 2010	-
market for polyethylene terephthalate, granulate, amorphous, recycled	CH; Europe without Switzerland; GLO; US	2010 - 2014	C
market for polyethylene terephthalate, granulate, bottle grade, recycled	CH; GLO	2014 - 2014	C
market for polyethylene, high density, granulate, recycled	CH; Europe without Switzerland; GLO; US	2010 - 2014	C
market for waste polyethylene terephthalate, for recycling, sorted	CH; Europe without Switzerland; GLO; US	2010 - 2014	C
market for waste polyethylene terephthalate, for recycling, unsorted	CH; Europe without Switzerland; GLO; US	2010 - 2014	-
market for waste polyethylene, for recycling, sorted	CH; Europe without Switzerland; GLO; US	2010 - 2014	C
market for waste polyethylene, for recycling, unsorted	CH; Europe without Switzerland; GLO; US	2010 - 2014	-
market for waste preparation facility	GLO	2000 - 2014	-

9 Updates in the remaining sectors

9.1 Agriculture

This sector experienced minor adjustment, focused on addressing concerns reported by our users regarding electricity consumption in cotton production and sheep modelling. Also, the units of "drying of maize grain" was changed to be aligned with the units of other existing drying activities (from m^3 to litres). This change affects the activities using "drying of maize grain" as well ("maize grain production").

Table 30. Activities where minor corrections have happened between v3.3 and v3.4. *If an activity is present with the same time period in several geographies all of them are listed under "Geography". The Reference product from each activity is listed as well. In the case of "drying of maize grain" units changed from m^3 to l. This reflects in the activities using this service.*

Activity name	Geography	Time period	Reference Product	
cotton production	CN; GLO; US	2000 - 2010	cotton fibre	U
drying of maize grain	CA-QC ; GLO	2000 - 2013	drying of maize grain	unit
maize grain production	CA-QC	2010 - 2012	maize grain	U
market for drying of maize grain	GLO	2000 - 2013	drying of maize grain	unit
sheep production, for meat	GLO; US	2001 - 2006	sheep for slaughtering, live weight	U
sheep production, for wool	GLO; US	2001 - 2006	sheep fleece in the grease	U

9.2 Building and refractory materials

In the context of the review and update of transforming activities for chemical products, the activities listed in Table 31 were updated using the same procedure as for the chemicals (described in chapter 5).

Table 31. List of updated transforming activities for building and refractory materials. *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 v3.4, "U" stands for "Updated", "D" means that only the documentation was improved, as either no new data could be found, or the data was considered to be representative of the current production process.*

Activity name	Geography	Time period	V3.4
cellulose fibre production, inclusive blowing in	GLO; CH	1995 - 2000	D
quicklime production, in pieces, loose	CH	2000 - 2002	D
silicon carbide production	GLO; RER	2000 - 2020	U

9.3 Metals

Some corrections were made in the metal sector, concerning electricity consumption (casting activities), inputs of quicklime (low-alloyed steel). Although small, the corrections have relevant impacts in the results of the LCIA methods.

In the context of the review and update of transforming activities for chemical products, activities related to extraction of ores and minerals were updated using the same procedure as for the chemicals (described in chapter 5).

Table 32. Updated activities in the metal sector. *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column. In the column v3.4, "U" stands for "Updated", "D" means that only the documentation was improved, as either no new data could be found, or the data was considered to be representative of the current production process. * indicates the Technology Level was also updated.*

Activity Name	Geography	Time period	V3.4
anodising, aluminium sheet	GLO, RER, CA-QC	1996 - 2003	U
barite production	GLO, RER, CA-QC	1978 - 2007	U
bentonite quarry operation	GLO, DE	1997 - 2000	U
boric acid production, anhydrous, powder	GLO, RER	2000 - 2020	U
casting, aluminium, lost-wax	CA-QC; GLO	2012 - 2012	U*
casting, steel, lost-wax	CA-QC; GLO	2012 - 2012	U
kaolin production	GLO, RER	2000 - 2000	D
magnesium oxide production	GLO, RER	2000 - 2000	U
portafer production	GLO, RER, CA-QC	2000 - 2000	D
silica sand production	GLO, DE	1998 - 2001	D
sodium chloride production, powder	GLO, RER	2000 - 2020	U
steel production, electric, low-alloyed	CA-QC	2011 - 2011	U

The dataset "integrated circuit production, logic type", GLO, had the input of wafer adjusted.

9.4 Transport

The dataset "transport, passenger car, EURO 3", RER has been corrected to adjust the mix it models, and also to update production volumes.

9.5 Waste treatment of organic waste

The anaerobic digestion of organic wastes and the composting are the main changes in this sector. Anaerobic digestion contained a serious mass imbalance, and this has been addressed in all cases, together with other corrections in emission calculations. Biowaste treatment activities have

been remodelled, or added new. In general, the LCIA scores associated to those activities have decreased with those updates.

Table 33. New and updated activities concerning organic waste treatment, listed with their respective reference products. *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 v3.4, "N" stands for "New", "U" stands for "Updated".*

Activity Name	Geography	Time period	Reference Product	V3.4
anaerobic digestion of manure	CH; GLO	2009 - 2009	biogas	U
treatment of biowaste by anaerobic digestion	CH; GLO	2011 - 2015	biowaste	N
treatment of biowaste, industrial composting	CH; GLO	2011 - 2015	biowaste	N
treatment of used vegetable cooking oil by anaerobic digestion	CH; GLO	2009 - 2009	used vegetable cooking oil	U

9.6 Wood and wood products

Minor updates and corrections have occurred in this sector, adjusting densities, yields, formulas and diesel consumption in some forestry data (this reduces greatly the impacts in some geographies)

Table 34. Updated activities in the wood sector. *If several geographies of the same activity with the same time period exist, all of them are listed in the "Geography" column.*

Activity Name	Geography	Time Period
hardwood forestry, beech, sustainable forest management	DE; GLO	2010 - 2012
hardwood forestry, birch, sustainable forest management	GLO; SE	2010 - 2012
hardwood forestry, mixed species, sustainable forest management	CH; GLO	2010 - 2012
hardwood forestry, oak, sustainable forest management	DE; GLO	2010 - 2012
softwood forestry, mixed species, sustainable forest management	CH; GLO	2010 - 2012
softwood forestry, pine, sustainable forest management	DE; GLO; SE	2010 - 2012
softwood forestry, spruce, sustainable forest management	DE; GLO; SE	2010 - 2012
sawing, hardwood	CA-QC; CH; GLO	2011 - 2013
sawing, softwood	CH; GLO	2011 - 2013

The product "cleft timber" is one of the most affected by the changed in terms of changes in the LCIA scores (GWP IPCC 2013). All equations modelling this product have been corrected for this release.

References

Althaus H.-J., Chudacoff M., Hischier R., Jungbluth N., Osses M. and Primas A., (2007) Life Cycle Inventories of Chemicals. ecoinvent report No. 8, v2.0. Swiss Centre for Life Cycle Inventories, Dübendorf, Switzerland

Bauer C., Bourgeault G., Wernet G., Treyer K., Vandepaer L., (2017) The electricity sector in ecoinvent version v3.4, ecoinvent, Zürich, Switzerland.

BP Amoco (2014) BP Statistical Review of World Energy June 2014. http://www.bp.com/statisticalreview

European Commission. (2016). EU Reference Scenario 2016. https://doi.org/10.2833/9127

Eurostat (2017) Energy Balances (2017 edition), http://ec.europa.eu/eurostat/web/energy/data/energy-balances

Faist Emmenegger M., Del Duce A., Moreno Ruiz E., Brunner F., (2017), Update of the European natural gas supply chains in v3.4, ecoinvent, Zürich, Switzerland.

Hischier R., Hellweg S., Capello C., Primas A., (2005), Establishing Life Cycle Inventories of Chemicals Based on Differing Data Availability, International Journal of Life Cycle Assessment, 10:59-67.

Hossain M.N, (2017). Regionalized Life Cycle Inventory of Power Producing Technologies and Power Grids in India, ecoinvent database version 3.4, ecoinvent, Zürich, Switzerland.

International Energy Agency, (2017), World Energy Statistics and Balances, OECD iLibrary, eISSN: 1683-4240, DOI: 10.1787/enestats-data-en

International Energy Agency, (2016), World Energy Outlook 2016. Paris. https://doi.org/10.1787/weo-2016-en

Kägi T., Zschokke M., Stettler C., (2017), Life Cycle Inventories for Swiss Recycling Processes - Part Carbotech: Recycling of Cardboard, Glass, PE, PET, Tinplate. On behalf of Federal Office for the Environment FOEN, Basel, Switzerland.

Treyer K., Bauer C., (2016), Life cycle inventories of electricity generation and power supply in version 3 of the ecoinvent database—part I: electricity generation, International Journal of Life Cycle Assessment, 21:1236–1254.

Treyer K., Bauer C., (2016), Life cycle inventories of electricity generation and power supply in version 3 of the ecoinvent database—part II: electricity markets, International Journal of Life Cycle Assessment, 21:1255-1268.

WEF, (2016), The New Plastics Economy - Rethinking the future of plastics, World Economic Forum, Cologny/Geneva, Switzerland.

Weidema B. P., Bauer C., Hischier R., Mutel C., Nemecek T., Reinhard J., Vadenbo C. O., Wernet G., (2013), Overview and methodology, Data quality guideline for the ecoinvent database version 3, ecoinvent Report 1(v3), St. Gallen: The ecoinvent Centre.

Wernet G., Hellweg S., Hungerbühler K., (2012), A tiered approach to estimate inventory data and impacts of chemical products and mixtures, International Journal of Life Cycle Assessment, 17:720-728.

Wernet G., Lévová T., Bourgault G., (2017), An update and extension of modeling of chemical production, ecoinvent database version 3.4, ecoinvent association, Zürich, Switzerland.

Zah R., Hischier R., (2007), Life Cycle Inventories of Detergents, ecoinvent report No. 12. Swiss Centre for Life Cycle Inventories, Dübendorf, Switzerland.