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Life cycle inventories of oil products distribution

BAFU, BFE & Erdöl-Vereinigung

Niels Jungbluth Dr. sc. Techn. Dipl. Ing. TU
ESU-services GmbH
T +41 44 940 61 32

CEO
Vorstadt 14
F +41 44 940 67 94

www.esu-services.ch
CH-8200 Schaffhausen
jungbluth@esu-services.ch

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Final report

Niels Jungbluth;Christoph Meili
ESU-services Ltd.
Vorstadt 14
CH-8200 Schaffhausen
Tel. +41 44 940 61 32
jungbluth@esu-services.ch
www.esu-services.ch

Customer

BAFU, BFE & Erdöl-Vereinigung

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Abbreviations

a	year (annum)
API	American Petroleum Institute
AZ	Azerbaijan
BAFU	Bundesamt für Umwelt
B(a)P	Benzo(a)Pyren
BAT	Best available Technologies
bbl	Barrel
bcm	billion cubic meters
bld	below limit of detection
bn	Billion
BEW	Bundesamt für Energiewirtschaft (Federal office for the energy industry)
BFE	Bundesamt für Energie
BOD5	Biochemical oxygen demand for 5 days of microbial degardation
BOOS	Burner Out Of Service
BTU	British Thermal Unit (1 BTU = 1055 J)
BTX	Benzene, Toluene, and Xylenes
Bq	Becquerel
BUWAL	Bundesamt für Umwelt, Wald und Landschaft; (Federal offices for environment, forest and landscape
CEL	Central European Pipeline
cf	Cubic Feet
CH4	Methane
CHP	Combined Heat and Power
Ci	Curie
CIS	Commonwealth of Independent States
CMC	Carboxymethyl Cellulose
CO	Carbon monoxide
CO2	Carbon dioxide
COD	Chemical oxygen demand
Concawe	Conservation of Clean Air and Water in Europe (the oil companies' European organization for environmental and health protection, established in 1963)
d	day
DeNOx	Dentirification method (general)
DGMK	Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V. (German scientific assosciation for oil, natural gas and coal)
DM	Dry matter
DoE	Department of Energy, US
dwt	Dead weight tons
E5/10/15/85•	Petrol with 5%/10%/15%/85% ethanol
EdF	Electricité de France
EdP	Electricidade de Portugal S.A.
EMPA	Swiss federal material testing institute
ENEA	Italian National Agency for New Technology, Energy and the Environment
EOR	Enhanced Oil Recovery

EOS SA	l'Energie de l'Ouest-Suisse
EPA	Environmental Protection Agency, US
FGD	Flue Gas Desulphurisation system
GGFR	Global Gas Flaring Reduction Partnership
GRT	Gross Registered Tonne
GWP	Global Warming Potential
HC	Hydro carbons
HEC	Hydroxyethyle cellulose
I.f.	insignificant fraction
IEA	International Energy Agency
IMO	International Maritime Organization
IPCC	International Panel on Climate Change
IQ	Iraq
J	Joule
KBOB	Koordinationsgremium der Bauorgane des Bundes
KZ	Kazakhstan
LCI	Life cycle inventory analysis
LCIA	Life cycle impact assessment
LRV	Luftreinhalte-Verordnung (Swiss Clean Air Act)
MEEPD	Ministry of the Environment, Environmental Protection Department
M.	Million
MJ	Megajoule
Mt	Megaton = 1 million tons
MTBE	Methyl tert-butyl ether
MW	Megawatt
MX	Mexico
NCI	Nelson complexity index
NDP	Norvegian Petroleum Directorate
NG	Nigeria
NGL	Natural Gas Liquids
NL	Netherlands
Nm3	Normal-cubic metre (for gases)
NMVOC	Non-Methane-Volatile Organic Compounds
NO	Norway
NOAA	National Oceanic and Atmospheric Administration
NORM	Naturally-Occuring Radioactive Materials
NOX	Nitrogen oxides
NR	Not Reported
Ns	not specified
OBM	Oil Based Mud,
OE	Oil equivalent
OECD	Organisation for Economic Cooperation and Development
OFA	Over Firing Air
PAH	Polycyclic Aromatic Hydrocarbons
PARCOM	Paris Commission
PC	Personal Communication
PM	Particulate Matter

PRTR	Pollutant Release and Transfer Register
RMPE	Royal Ministry of Petroleum and Energy Norway
Rn	Radon
RODP	Relative Ozone Depletion Potential
RSO	Raffinerie du Sud-Ouest SA
RU	Russia
SA	Saudi-Arabia
SEPL	South European Pipeline
SMA	Schweizerische Meteorologische Anstalt (Swiss Meterological Institute)
SN	Smoke number
SNCR	Selective-Non-Catalytic-Reduction
SPCA	State Pollution Control Authority
SPSE	Société du pipeline sud-européen (South European Pipeline)
SRE	Société Romande d'Electricité
SRI	Sustainable Recycling Industries
TDS	Total Dissolved Solids
TEL	Tetraethyl lead
toe	Ton Oil Equivalent
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
UBA	Umweltbundesamt (Federal Office for the Environment)
UCTE	Union for the Co-ordination of Transmission of Electricity
ULCC	Ultra Large Crude Carrier
ULS	Ultra low sulphur
UNEP	United Nations Environment Programme
Unipede	International Union of Producers and Distributors of Electrical Energy
US (A)	United States of America
UVEK	Federal Department for Environment, Transport, Energy and Communications
VDEW	Vereinigung Deutscher Elektrizitätswerke e.V. (Union of German Electricity Works)
VEÖ	Verband der Elektrizitätswerke Österreichs (Association of Austrian Electricity Works)
VFWL	Verein zur Förderung der Wasser- und Lufthygiene (Society to Support Water and Air Hygiene)
VLCC	Very Large Crude Carrier
VOC	Volatile Organic Compounds
VVS	Verordnung über den Verkehr mit Sonderabfällen, (Regulation on handling of hazardous wastes)
WBM	Water Based Mud,
WEC	World Energy Council

Indices

e	electric
End	End energy
In	Input, related to a energy converter (end energy)
Nutz	useful energy
Out	Output, related to an energy converter (useful energy or end energy)
therm	thermal

1 Overview

1.1 Introduction

This document is the updated version of the ecoinvent data v2.0 (Jungbluth 2007). The German report has been translated in 2012 by Franziska Peter, PSI for the ecoinvent centre. This English translation forms the starting point for updating the data with the reference year 2016.

The goal of the report is to report the data as they are investigated with this update. Thus, the reader should have a full overview about the data sets as they are now provided for the KBOB database.

In general, subchapters on process steps that are assessed as relevant in the final LCIA results (ecological scarcity 2013) were kept or updated in this report.

If the numbers did not change considerably or no new numbers were available, the former text was kept for this report to provide this relevant information.

Technical descriptions in the former report often were elaborated for the 1996 version of the data (Frischknecht et al. 1996). They often seemed to be outdated and such descriptions which are not relevant for the estimates have been deleted.

Parts of the text which are not relevant (anymore) for the final estimation of the life cycle inventory have been removed to improve the readability of the new report and shorten the amount of documentation. This concerns e.g. long literature lists of data sources dating back to the 80ies if up-to-date data were available. This concerns also annexes with long documentation of data which finally were not used for a new estimation in this report. If no new information was available only the final estimation is documented to improve the readability. The documentation focuses on aspects which are relevant for the updated life cycle inventories presented in this report.

To keep this report readable outdated and old information has been removed partly. If LCI data are still based on such very old information they are cited as (Jungbluth 2007) which means they often have been published before the year 2000.

Changes made to ecoinvent v2.0 data and implemented in ecoinvent v3 are NOT part of this report. Therefore, the content of this document does not reflect the LCI data of ecoinvent v3.

The life cycle inventory analysis for the distribution of mineral oil products to the end user is modelled in this report. Therefore, the supply of refinery products is investigated for Switzerland and for Europe. The modelling starts at the refinery gate and ends when the fuel is provided to the end user (tanks of cars, trucks, oil heating, etc.).

The modelling follows largely the assumptions made in the previous version for ecoinvent data v2.2 (Jungbluth 2007). All updates compared to this version are described in this report.

For datasets dealing with the distribution of mineral oil products, updates have been made concerning the share of products imported to Switzerland and the associated transports. Furthermore, an update for the fugitive air emissions has been made. Another important point is the consideration of blending of fossil fuels with biofuels according to the present situation on the market.

The following products are investigated until the regional storage. For fuels this is equal to the filling station:

- diesel

- heavy fuel oil
- kerosene
- light fuel oil
- naphtha
- petrol
- petrol, two-stroke blend

1.2 Product properties

Information about product properties for mineral oil products is specified for these products in the report on refinery processing (Jungbluth et al. 2018).

Due to blending of mineral oil products with biogenic fuels, a part of the carbon is biogenic. This share is shown in Tab. 9.3 and Tab. 9.4 of this report.

2 Market mixes

2.1 Market for fuels

2.1.1 Switzerland

By 2016, there were 3,424 filling stations in Switzerland. The number of filling stations in Switzerland has been declining since 2011. As presented in Tab. 2.1, in 2016, about 7.78 million tons of refinery products were imported to Switzerland. The full list of refinery products (e.g. petrol, diesel, kerosene, etc.) is defined in the report on refineries (Jungbluth et al. 2018).

About half of them are produced in Germany (53.8%). The other half is imported mostly from other European countries (45.9%) (Erdöl-Vereinigung 2017). The figures given in this publication are not exactly the same as published by CARBURA (2017). There might be differences because of the unit m3 instead of tonnes and the unknown conversion factor. But, the tendency is the same. Thus, the data of Erdöl-Vereinigung, which are shown with the right unit, are considered for the further calculations.

Tab. 2.1 Tons of refinery products imported to Switzerland in 2016 (Erdöl-Vereinigung 2017). Thousand m3 of products imported to Switzerland in 2016 (CARBURA 2017)

Origin	Tons of products	% of all products	1000 m3	% of all products
Germany	4'184'383	53.8	5'010	54.7
Belgium	1'092'065	14.0	1'226	13.4
France	940'530	12.1	1'106	12.1
Italy	786'609	10.1	942	10.3
Netherlands	668'782	8.6	772	8.4
other EU-count	85'881	1.1	88	1.0
other non-EU-c	19'658	0.3	11	0.1
Total	**7'777'908**	**100.0**	**9'155**	**0.1**
	Erdöl-Vereinigung 2017		Carbura 2017	

Since 2015 only one refinery in Cressier[1] (earlier known as Raffoil) is operating in Switzerland. Data for the domestic refinery product output in Cressier, imports and consumption is presented in Tab. 2.2 (Erdöl-Vereinigung 2017). With this also the share of fossil and biogenic fuels for the Swiss consumption has been calculated.

Tab. 2.2 Tons of refinery products produced for the Swiss market and imported in 2016 (Erdöl-Vereinigung 2017), calculated shares of fossil and biogenic fuels for total consumption

Tonnes of product in 2016	domestic production	imports	total consumption	shares
	t	t	t	%
petrol	723'267	1'718'832	2'442'099	98.89%
ethanol	-	27'290	27'290	1.11%
diesel oil	873'672	1'798'328	2'672'000	97.42%
biodiesel	7'787	63'051	70'838	2.58%
light fuel oil	819'022	1'756'333	2'575'355	
heavy fuel oil	2'770	569	3'339	
propane/ butane (liquid gases)	98'410	n.a.	n.a.	
kerosene	45'165	1'670'820	1'715'985	
benzene	-	n.a.	n.a.	
Other distillates and products	50	n.a.	n.a.	
naphtha	5'151	13'543	18'694	
secondary sulphur	5'265	n.a.	n.a.	
bitumen	-	n.a.	n.a.	
refinery gas	n.a.	n.a.	670'000	
others		-		
Total	**2'580'559**	**7'615'041**	**10'195'600**	

2.1.2 Europe

It is assumed that the mineral oil products consumed in Europe are produced in European refineries as data for other continents were not available.

2.2 Blending of refinery products with biofuels

Upgrading and blending of mineral oil products is inventoried newly in this chapter. The blending of refinery products is investigated with average data for the supply of automotive fuels. Therefore, no subtraction is made for the separate supply of "green products" such as E10.

It is expected that in the future the introduction of synthetic fuels made with hydrogen produced by electrolysis with renewable electricity might be relevant. Thus, the blending of petrol and diesel with different types of inputs on the market will become a more important issue.

2.2.1 Switzerland

In 2016 fossil fuels are blended in Switzerland before they are sold on the market. Statistical data as shown in Tab. 2.2 and Tab. 9.3 are available for the amount of biofuels (Eidgenössische Zollverwaltung 2017) and the share of imported fuels (Erdöl-Vereinigung 2017):

- Diesel is blended with about 2.6% of biodiesel
- Petrol is blended with about 1.1% of bioethanol

[1] Personal communication Daniel Märki, Petroplus Refining Cressier SA, CH, (www.petroplus.ch).

- For heating oil there are some offers for biogenic oils by traders, but so far, no statistical information concerning the share and type of biodiesel sold for this purpose is available for Switzerland.

2.2.2 Europe

Biofuel consumption for transport increased slightly in 2016. EurObserv'ER's preliminary estimates suggest the figure of 14.4 million toe (Ton Oil Equivalent), which equates to 1.3% year-on-year growth. This increase was entirely driven by biodiesel consumption (which rose 2.4% to 11.6 Mtoe), as bioethanol consumption slipped (by 3.1% to 2.6 Mtoe).[2] The consumption of biofuels in different countries is shown in Fig. 2.1.

[2] https://www.eurobserv-er.org/category/all-biofuels-barometers/, 26.9.2017

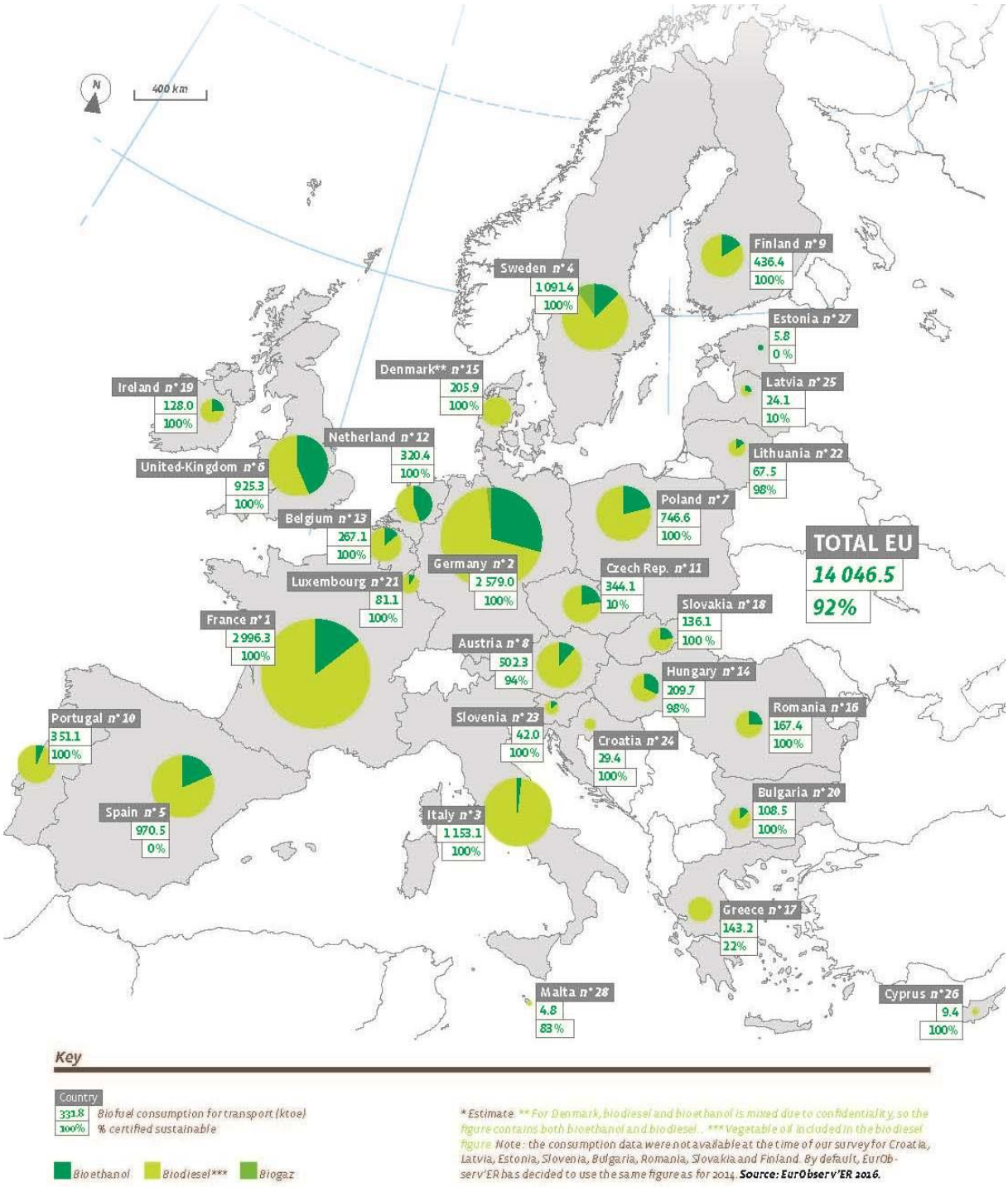

Fig. 2.1 Biofuels consumption for transport in the European Union in 2016 (in toe)[3]

The data shown in Tab. 2.3 form the basis for the assessment of the fuel mixes in Europe (e.g. European Commission 2017). Statistical data on blending for the European market have been published by the OECD for the years 2012-14.[4]

[3] EurOberv'ER Biofuels barometer 2017: https://www.eurobserv-er.org/pdf/biofuels-barometer-2016-en/

[4] www.dx.doi.org/10.1787/888933229833 and www.dx.doi.org/10.1787/888933229825

The mix of biofuel production paths was not updated yet. Data would be available e.g. in the Biofuel-Barometer and by the European Commission (2017).

Tab. 2.3 Data for the biofuel consumption in Europe and estimation for this study

	Mix	*Production capacities*	*Consumption*	*Consumption*	*Consumption*	*Consumption*	*Consumption*	*Consumption*	*Consumption*	*Consumption*	***Mix, This study***
	RER	*RER*	*RER*	*RER*	*RER*	*RER*	*RER*	*RER*	*RER*	*RER*	***RER***
	2012-14	*2015*	*2014*	*2014*	*2015*	*2015*	*2015*	*2016*	*2016*	*2016*	***2016***
	Vol	*1000 t*	*ktoe*	*%*	*Mio. t*	*toe*	*%*	*toe*	*toe*	*%*	***%***
ethanol	4.5%	5.86E+3	2'657	3.3%		2'600'000	3.1%	2'729'832		3.3%	**3.3%**
petrol	95.5%		79'000	96.7%	81		96.9%		81'000'000	96.7%	**96.7%**
biodiesel	5.7%	2.23E+4	11'342	5.5%		10'900'000	3.8%	11'335'027		5.5%	**5.5%**
diesel	94.3%		195'107	94.5%	273		96.2%		195'000'000	94.5%	**94.5%**
Total			288'106								
Source	OECD-FAO Agricultural Outlook 2015				Bericht des Mineralölwirtschaftsverbandes (MWV), S 85	EU progress report	Own calculation	Biofuel Barometer	Own best guess	Estimation	Data for 2014 and 2016
Link	www.dx.doi.org/10.1787/888933229833	http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do	https://ec.europa.eu/energy/sites/ener/files/documents/pocketbook_energy-2016_web-final_final.pdf (S. 112 ff)		https://www.mwv.de/wp-content/uploads/2017/09/170918_Mineralolwirtschaftsverband_Jahresbericht-2017.pdf	https://ec.europa.eu/energy/en/topics/renewable-energy/progress-reports		https://www.eurobserv-er.org/category/all-biofuels-barometers/			

2.2.3 Special blends

The following products, which were investigated in a former project on biofuels (Jungbluth et al. 2007) are included in the ecoinvent data v2.2. They are presently not relevant for the Swiss market.[5] Thus, no updates have been made to these products:

- Petrol with ethyl-tert-butyl-ether (ETBE)
- Petrol with 5%/85% Ethanol (E5 / E85)
- Diesel with 100% rapeseed oil methyl esters (RME)

A new product on the European market would be E10.[6] E10 is currently available in Belgium, Finland, France and Germany. E10 is now 32% of petrol sales in France and 63% in Finland. Its share of the petrol market in Germany was 12.6% in 2016. In the countries where E10 (petrol with 10% ethanol) is available, it is a few cents cheaper than E5 and there is no difference in fuel consumption between E10 and E5 petrol grades. E10 is also being used in the U.S., Australia and New Zealand. In Brazil the percentage of ethanol used in petrol can be even as high as 25%. The U.S. is also moving towards introducing E15 (petrol with 15% ethanol).

No investigation of these mixes was foreseen for this project. They can be easily modelled by adapting the LCI for the present blend of petrol (or diesel) accordingly.

2.3 Share of biomass feedstocks for blending

2.3.1 Switzerland

In Switzerland, all sold liquid biofuels were produced from residuals or wastes. This is due to the present legislation for exemption on the mineral oil taxes. Available information about the

5 „Less than 1% of petrol stations have an E85 petrol pump at all and they are also less frequented. The Petroleum Association considers E85 Group as of 2016 negligible “ (Personal communication Martin Joss, Erdölvereinigung, 17.11.2017)

6 http://epure.org/about-ethanol/fuel-market/fuel-blends/

biomass feedstocks for biofuels is shown in Tab. 2.4. It must be noted that quantitative information for the used feedstocks is only available for the part of biofuels which enters the market. This information has been used to assess the share of different feedstocks for biofuels used in Switzerland.

Adequate LCI data for these types of feedstocks are only partly available and thus assumptions had to be taken in the inventory as shown in Tab. 9.3. For this study it is assumed that biodiesel is produced from waste plant oil and ethanol is produced from wood and sugar cane molasses. The total amount of biofuels entering the Swiss market is not estimated with Tab. 2.4 but with information provided in chapter 2.2.1.

Tab. 2.4 Biomass feedstocks for a part of biofuels used in Switzerland in 2016[7]

1000 l in 2016	Total	wood waste (Scandinavia)	Others: Pentosane, starch (NL) grape trester (IT)
Ethanol	38'277'089	7'763'245	30'513'844
		20.3%	79.7%

	Total	UCO (used cooking oil)	Others (Glyzerin/ Free Fatty Acides (FFA))
Biodiesel (CH, RER, US)	58'698'463	30'079'601	28'618'862

		UCO/slaughter waste	
HVO (Hydrogenated oder Hydrotreated Vegetable Oils)	11'069'630	11'069'630	
Total	108'045'181		

2.3.2 Europe

Information from a report of the EC (European Commission 2017) was used to assess the share of different feedstocks for biofuels. The share of feedstocks for biodiesel and ethanol in 2014 is shown in Tab. 2.5. Only data for biodiesel are used according to this source as more recent data were available for ethanol as shown in Fig. 2.2.

Data regarding the disaggregation by feedstock for production of bioethanol and biodiesel consumed in the EU differs depending on information source. All available sources however confirm that EU ethanol is mainly produced from wheat, maize and sugar beet, and that in 2014, more than 50% of biodiesel consumed in the EU was produced from rapeseed. At the same time, the use of waste oils and fats and also of palm oil has significantly increased since 2010. In accordance with industry data, more than 60% of biodiesel and more than 90% of bioethanol consumed in the EU was produced from the EU feedstock.

In accordance with Directive (EU) 2015/1513 of 9 September 2015 (so-called ILUC Directive), the Commission is required to report on biofuel GHG emissions, including ILUC emission by using feedstock data from the 'Member States' reports due by end of 2017. Since the transposition of Directive (EU) 2015/153 is not yet complete and the member states have not yet started reporting the required data, the Commission based its assessment on data from

[7] Data provided by Martin Joss, Erdölvereinigung, in October 2017. Compilation of raw materials from the CO_2 compensation program Klick. The difference between the OZD figures and those of Klick of ~15 million litres are liquid fuels that do not participate in the compensation programme.

Eurostat (amounts of biodiesel, other liquid biofuels and biogasoline consumed in the EU) and data from the feedstock mix from USDA FAS 2016 and industry data.

Non –EU bioethanol feedstock is imported from Ukraine (maize, wheat), Canada (wheat), Russia and Moldova (barley, ray), and Serbia (sugar beet). The largest exporters of biodiesel feedstock to the EU were Indonesia and Malaysia (palm oil), Brazil and the US (soybean). The majority of rapeseed oil is of EU origin. Feedstock potential for advanced renewable fuels is large, but production facilities at commercial scale are still limited.

Tab. 2.5 Share (by weight) of domestic and imported feedstocks for biofuel production in Europe in 2014 (European Commission 2017)

Domestic and imported feedstock (in 2014)	*Feedstock mass (1,000 MT)*	*Share of bioethanol/ biodiesel (%)*
Bioethanol		
Wheat	2,798	22%
Corn	5,174	47%
Barley	541	4%
Sugar Beet	9,364	20%
Rye	846	6%
Cellulosic Biomass	270	1%
Total bioethanol	**18,993**	**100%**
Biodiesel		
Rapeseed oil	6,100	52%
UCO	1,800	15%
Palm oil	1,580	13%
Soybean oil	890	8%
Animal fats	920	8%
Sunflower oil	320	3%
Other (pine oil, fatty acids)	170	1%
Total biodiesel	**11,780**	**100%**

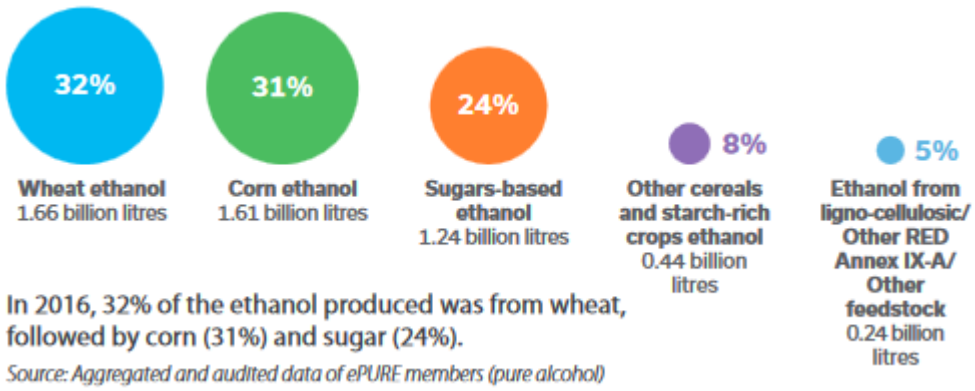

Fig. 2.2 Share (by volume) of European renewable ethanol produced from each feedstock type[8]

The above information has been used to model unit process raw data in Tab. 2.6 for the mix of biofuels used in Europe.

8 http://epure.org/media/1610/2016-industry-statistics.pdf

Tab. 2.6 Unit process raw data for the mix of raw materials used for biofuels in Europe. For ethanol the distillation from 95% to 99.7% purity is included in the inventory

Explanations	Name	Location	InfrastructureProcess	Unit	ethanol, 99.7% in H2O, from biomass, at distillation	methyl ester, from biogenic oils, mix, at regional storage	uncertainty Type	StandardDeviation95	% GeneralComment	*Shares biomass feedstock*	*Shares biomass feedstock*
	Location				RER	RER				*RER*	*RER*
	InfrastructureProcess				0	0				*2014*	*2016*
	Unit				kg	kg				*%*	*%*
Outputs product	ethanol, 99.7% in H2O, from biomass, at distillation	RER	0	kg	1.00E+0	0					
	methyl ester, from biogenic oils, mix, at regional storage	RER	0	kg	0	1.00E+0					
Technosphere	heat, natural gas, at industrial furnace >100kW	RER	0	MJ	1.02E+0	0	1	1.21	(1,2,1,1,1,5); etha+ project Alcosuisse, industrial data		
	electricity, low voltage, production ENTSO, at grid	ENTSO	0	kWh	9.15E-3	0	1	1.21	(1,2,1,1,1,5); etha+ project Alcosuisse, industrial data		
	ethanol fermentation plant	CH	1	unit	5.30E-11	0	1	3.05	(1,2,1,1,1,5); etha+ project Alcosuisse, industrial data		
	treatment, sewage, from residence, to wastewater treatment, class 2	CH	0	m3	4.96E-5	0	1	1.21	(1,2,1,1,1,5); etha+ project Alcosuisse, industrial data		
	ethanol, 95% in H2O, from rye, at distillery	RER	0	kg	32%	0	1	1.00	(1,1,1,1,1,1); Wheat	22%	32%
	ethanol, 95% in H2O, from corn, at distillery	US	0	kg	31%	0	1	1.05	(1,1,1,1,1,1); Corn	47%	31%
	ethanol, 95% in H2O, from rye, at distillery	RER	0	kg	4%	0	1	1.05	(1,1,1,1,1,1); Barley	4%	4%
	ethanol, 95% in H2O, from sugar beets, at fermentation plant	CH	0	kg	24%	0	1	1.05	(1,1,1,1,1,1); Sugar beet	20%	24%
	ethanol, 95% in H2O, from rye, at distillery	RER	0	kg	4%	0	1	1.05	(1,1,1,1,1,1); Rye	6%	4%
	ethanol, 95% in H2O, from wood, at distillery	SE	0	kg	5%	0	1	1.05	(1,1,1,1,1,1); Cellulosic biomass	1%	5%
	rape methyl ester, at esterification plant	RER	0	kg	0	52%	1	1.05	(1,1,1,1,1,1); Rape oil	52%	
	vegetable oil methyl ester, at esterification plant	FR	0	kg	0	15%	1	1.05	(1,1,1,1,1,1); UCO (waste oils)	15%	
	palm methyl ester, at esterification plant	MY	0	kg	0	13%	1	1.05	(1,1,1,1,1,1); Palm oil	13%	
	soybean methyl ester, at esterification plant	BR	0	kg	0	8%	1	1.05	(1,1,1,1,1,1); Soybean oil	8%	
	vegetable oil methyl ester, at esterification plant	FR	0	kg	0	8%	1	1.05	(1,1,1,1,1,1); Animal fat	8%	
	soybean methyl ester, at esterification plant	BR	0	kg	0	3%	1	1.05	(1,1,1,1,1,1); Sunflower	3%	
air, high population density	Heat, waste			MJ	3.29E-2	0	1	1.14	(2,4,1,3,1,3); ecoinvent guidelines, calculation from electricity consumption and energy balance		
										European Comission 2017	www.epure.org/media/1610/2016-industry-statistics.pdf

2.4 Additives

Most additives are inventoried as described in the report for refinery processing (Jungbluth et al. 2018). Only the use of MTBE is considered at this stage.

- Tapping resistance, methyl tertiary butyl ether (MTBE):

MTBE is added to unleaded petrol in concentrations of no more than 15% by weight due to economic considerations. According to BFS (2002), the content of super gasoline is 8% or 1.7% MTBE for super gasoline and normal gasoline, respectively. The Cressier refinery currently uses 6.7%. The total imports to Switzerland amount to 47.6 tsd tonnes. The average addition in Europe in 2001 is 2.1% by weight.[9] The lower heating value is 35.1 MJ/kg (Edwards et al. 2014).

3 Infrastructure

No updates compared to the previous version have been commissioned for this study because of minor importance. No information was available and this issue is of minor importance (Jungbluth 2007).

The average storage time is 2 months. Thus, total through flow in the life time is 2.4 mio. m^3. The unit process raw data are shown in Tab. 3.1. The total size of tank storage capacity in Switzerland in 2015 was 7.5 Mio. m^3 (CARBURA 2017).

Tab. 3.1 Unit process raw data for the infrastructure. Bottom-Up estimation based on plant data. Life time is 40 years. Product storage volume of storage tanks is 10'000 m3.

	Name	Location	InfrastructureProcess	Unit	*regional distribution, oil products*	Uncertainty	StandardDeviation95%	GeneralComment
	Location				*RER*			
	InfrastructureProcess				*1*			
	Unit				*unit*			
product	regional distribution, oil products	RER	1	unit	1.00E+0			
resource, land	Occupation, industrial area, built up	-	-	m2a	2.00E+5	1	5.10	(3,5,5,1,1,5); Literature, life time 80 years
	Occupation, traffic area, road network	-	-	m2a	4.59E+6	1	3.33	(3,5,5,1,1,5); Literature, life time 80 years
	Transformation, from unknown	-	-	m2	5.98E+4	1	4.01	(3,5,5,1,1,5); Literature
	Transformation, to industrial area, built up	-	-	m2	2.50E+3	1	4.01	(3,5,5,1,1,5); Literature oil storage
	Transformation, to traffic area, road network	-	-	m2	5.73E+4	1	3.33	(3,5,5,1,1,5); Literature fuel station
technosphere	concrete, sole plate and foundation, at plant	CH	0	m3	4.55E+2	1	3.33	(3,5,5,1,1,5); Literature
	gravel, round, at mine	CH	0	kg	3.00E+5	1	3.33	(3,5,5,1,1,5); Literature
	reinforcing steel, at plant	RER	0	kg	2.00E+5	1	3.33	(3,5,5,1,1,5); Literature
	bitumen, at refinery	RER	0	kg	7.50E+4	1	3.33	(3,5,5,1,1,5); Literature
	disposal, asphalt, 0.1% water, to sanitary landfill	CH	0	kg	3.00E+5	1	3.33	(3,5,5,1,1,5); Literature
	disposal, concrete, 5% water, to inert material landfill	CH	0	kg	1.00E+6	1	3.33	(3,5,5,1,1,5); Literature
	disposal, bitumen, 1.4% water, to sanitary landfill	CH	0	kg	7.50E+4	1	3.33	(3,5,5,1,1,5); Literature
	transport, lorry >16t, fleet average	RER	0	tkm	1.48E+5	1	3.76	(4,5,na,na,na,na); Standard distance 50km
	building, hall	CH	1	m2	1.43E+4	1	5.24	(5,na,5,1,1,na); Estimation 25% of fuel station area

It can be assumed that kerosene and heating oil are not distributed via local filling stations and thus the demand for infrastructure is reduced by 50% as a rough assumption. The following demands for infrastructure are calculated with these assumptions (Jungbluth 2007).

9 http://www.mtbe.de/zusammensetzung.html

Tab. 3.2 Estimation for the use of infrastructure per $kg_{Product}$

Product	Density	Input of infrastructure
	kg/l	unit/kg
Petrol	0.75	5.56E-10
Diesel	0.84	4.96E-10
Others	1	2.08E-10
Life time	years	40

4 Energy use

The electricity use is estimated with 0.00084 MJ/MJ_{fuel} for fuel depot plus 0.0034 MJ/MJ_{fuel} for dispensing at retail site (Edwards et al. 2014) which equals 51 Wh per kg. No updates have been made for the heat use in distribution compared to the previous version because no information was available and this issue is of minor importance (Jungbluth 2007; Shell 2000a, b).

5 Emissions to air

5.1 Fugitive emissions

The sources of emissions to air during storage and distribution of oil products are described in the former report (Jungbluth 2007). All such emissions from refinery until distribution to the customer are considered here.

The amount of total VOC emissions for gasoline during local distribution and dispensing is estimated with 0.12% (Edwards et al. 2014).

The amount of total VOC emissions for other products has been updated with a publication for Germany (Winkler 2004). This study makes already first estimates for the reduction of emissions due to petrol vapour recovery. Newer measurements or estimates for such emissions were not found.

Tab. 9.3 and Tab. 9.4 show the fugitive emissions due to the handling of mineral oil products. An accordingly amount for the VOC losses has been added as an additional mineral oil product input in the dataset.

The Swiss organisation CERCLAIR describes technical recommendations for the reduction of such emissions[10], but measurements or estimations for the total or specific emissions were not available.

The profile of VOC emissions for petrol in Tab. 5.1 has been newly estimated considering the more detailed information cited as Edwards et al. 1986 and shown in a report[11] on “Extraction and distribution of fossil fuels and geothermal energy”. Furthermore the formerly (Jungbluth 2007) used information is taken into account for this estimate (Carter et al. 2002; Frischknecht et al. 1996). Thus the new estimation is more in the range of the data presented in the first version of these data (Frischknecht et al. 1996).

10 https://cerclair.ch/assets/src/pdf/22_2012_D_Tankstellen.pdf
11 https://www.eea.europa.eu/publications/technical_report_2001_3/group05.pdf

For other products no specifications for single VOC were available.

Tab. 5.1 VOC-Profile of emissions from petrol handling

	This study	Estimation	Gasoline Composition	Full shift exposure Road Tank Driver	VOC profiles of gasoline terminal air sample
Location	RER	RER	RER	RER	
Unit	%	%	% v/v	mg/m3	%
Hydrocarbons, aliphatic, alkanes, unspecified	79.9%	80.0%			89.20%
Hydrocarbons, aliphatic, unsaturated	6.9%	10.0%			6.90%
Hydrocarbons, aromatic	1.0%	1.0%	36.2%		
Benzene	1.0%	2.0%	0.8%	0.60	1.10%
Methane, fossil	0.03%	0.03%			
t-Butyl methyl ether	5.0%	5.0%			
Toluene	2.0%	2.0%	10.4%	1.40	2.00%
Xylene	0.8%	0.0%	11.1%	0.60	0.8%
Benzene, ethyl-	2.1%	0.0%	2.1%		
Hexane	1.3%	0.0%	1.3%	0.80	
NMVOC, non-methane volatile organic compounds, unspecified origin	100.0%	100.0%			100.0%
Source		(Frischknecht et al. 1996)	(Carter et al. 2002)	(Carter et al. 2002)	(Edwards et al. 1986)

5.2 Credit for biogenic carbon content

The blending described in chapter 2.2 has negligible impact on the general properties of the fuel, but it changes the share of fossil and biogenic carbon in the products and thus the emissions in all processes using these products. The change of this product property has in principle an influence on all datasets using these products (transport services, building machines, combined heat and power plants).

Thus a methodological clarification had to be made how to consider these changes in view of the KBOB database (KBOB v2.2: 2016). The simple intermediate solution used here is to introduce a negative fossil CO_2 and equivalent biogenic CO_2 emission in the blending dataset to avoid changing all datasets depending on these fuel properties.

The biogenic carbon content for ethanol and methyl ether has been defined in a former study (Jungbluth et al. 2007) and is shown in Tab. 9.3. The emission of biogenic carbon dioxide per kg of fuel in Tab. 9.4 is calculated with amount of biogenic fuel and the associated CO_2-emissions per kg of biogenic fuel (biogenic carbon content in Tab. 9.3).

The credit for the fossil carbon dioxide emissions in Tab. 9.4 is calculated according to the amount of fossil fuel (diesel or petrol) replaced in the mix with biogenic fuel. As CO2 emission per kg for fossil and biogenic fuels are not totally the same, there are slight differences between the biogenic CO_2 emission and the credit for fossil CO_2.

It must be clarified, if and how in future ecoinvent v3 product property routines can deal with this situation as it can be expected that the share of biogenic carbon will change with each update of these datasets. Furthermore, this issue needs to be tackled if inventories for processes using diesel and petrol are updated. Than, the CO_2 emissions need to be newly calculated according to the specifications in this report and the new specifications for CO_2 emissions (Jungbluth et al. 2018).

6 Emissions to water

No updates have been made compared to the previous version because no information was available and this issue is of minor importance (Jungbluth 2007).

7 Wastes

No updates have been made compared to the previous version because no information was available and this issue is of minor importance (Jungbluth 2007).

8 Transports and origin of products

8.1 Switzerland

In this chapter transports from refinery to the final distribution point (e.g. filling station) are calculated. Tab. 8.1 shows the estimation for transport distances of products sold in Switzerland. This results in a total 657 km for the import of 1kg of product to the Swiss border. The share of different modes of transport for the products imported from Europe to Switzerland has been estimated with the available statistics presented in chapter 2.1.1, Tab. 2.1 (Erdöl-Vereinigung 2017).

For transport distances from refineries to the Swiss border, estimates for petrol and diesel are available (Stolz & Frischknecht 2017). The estimate for all refinery products in this study lies inbetween of these values.

In the former and in a current study, a value of 0.15 tkm/kg for the transport from border or refinery to the central storage and then to the filling station is assumed (Jungbluth 2007; Stolz & Frischknecht 2017). This value for transport by truck is the same as the European value estimated in a study done by the oil industry (Edwards et al. 2014).

At Zurich Airport, which is the most important airport in Switzerland, kerosene is supplied to most of the aircrafts via an underfloor refuelling system. An underground pipeline lead from the tank farm in Rümlang, which is supplied by rail, to the docks.[12] The distance by pipeline is estimated with 2 km. Another 1 km by truck is added to this figure for the supply of kerosene to aircrafts.

According to the freight traffic survey of BFS[13] in 2016, total transport of mineral oil products by truck in Switzerland accounted for about 425 million tkm. Divided by total production of other refined products for the Swiss market (see Tab. 2.2), this results in 0.05 tkm/kg of the other fuels and heating oil. This value is much lower and more specific than the values estimated before. It is used in this study. However, it is assumed, that in addition to the transport by truck, the refined oil is also transported about 0.03 tkm/kg by train.

The origin of biofuels imported to Switzerland is shown in Tab. 8.2. Most of the biofuels come from European countries and the share of biofuels is still small. Thus, it is estimated that no adaptations for this small share are necessary and the estimation made in Tab. 8.1 can be used.

12 https://www.nzz.ch/articleECNCI-1.52229, assessed 17.5.2016

13 https://www.bfs.admin.ch/bfs/de/home/statistiken/mobilitaet-verkehr/gueterverkehr.assetdetail.3802389.html, online, 16.05.2018

Tab. 8.1 Transports for imported mineral oil products estimated for the year 2016 based on the amounts provided in statistics and own estimations for distances

Products imported from Europe to Switzerland		Share	Origin	Estimated distance origin to CH	Estimated distance petrol	Estimated distance diesel	Imports	Distribution in Switzerland
	t	%		km	tkm/kg	tkm/kg	tkm/kg	tkm/kg
Train	3'552'338	46.9%	DE, BE, IT	600	0.207	0.182	0.281	0.030
Truck RER	665'576	8.8%	IT, DE	500	0.081	0.056	0.044	0.000
Truck CH	-	0.0%			0.150	0.150	0.000	0.050
Barge tanker	2'491'483	32.9%	DE, NL, BE	800	0.115	0.316	0.263	0.000
Transoceanic tanker	-	0.0%			0.000	0.000	0.000	0.000
Airplane	-	0.0%			0.000	0.000	0.000	0.000
Pipeline Onshore	866'206	11.4%	FR	600	0.032	0.056	0.069	0.000
Total	**7'575'603**	**100%**			**0.585**	**0.760**	**0.657**	**0.080**
	Erdöl-vereinigung 2017			This study	Stolz 2017	Stolz 2017	This study	This study

Tab. 8.2 Origin of biofuels imported to Switzerland (Eidgenössische Zollverwaltung 2017)

Produkt		Deutschland	Frankreich	Holland	Norwegen	Österreich	Italien	Schweden	Vereinigtes Königreich	China	Vereinigte Staaten	Total
Reine Biotreibstoffe:												
Biogas	[1]	-	-	-	-	-	-	-	-	-	-	-
Biodiesel	[2]	53 286	8 479	-	-	1 951	-	-	43	243	355	64 357
Bioethanol	[2]	425	-	24 254	6 440	-	5 864	1 295	-	-	-	38 278
Hydrierte pflanzliche und tierische Öle oder Fette	[2]	121	-	-	-	-	-	112	-	-	11 070	11 303
pflanzliche und tierische Öle	[2]	-	-	-	-	-	-	-	-	-	-	-
beigemischter Bioanteil:												
im Benzin	[2]	-	-	-	-	-	-	-	-	-	-	-
im Dieselöl	[2]	-	-	-	-	-	61	-	-	-	-	61
in Biotreibstoffgemische (>30% biogener Anteil)	[2]	-	-	10 120	-	-	1 311	-	-	-	-	11 431

8.2 Europe

The transport for the distribution of European products was formerly estimated with a total of about 113 km based on a report by a distributor (Jungbluth 2007; Shell 2000a, b). But, this seems to underestimate the distances. The actual estimation for this study is based on the share and distances used in a study by the oil industry (Edwards et al. 2014). The total transport distance is thus 600 km with different types of transport services. The data is shown in Tab. 8.1.

For kerosene also smaller distances by truck and larger distances by pipeline and train are roughly estimated in order to consider that large airports often have own storages for it. The overall distance is assumed to be the same as for other fuels.

Tab. 8.3 Transports for mineral oil products estimated for the year 2016

Distribution in Europe	Distribution Europe	Distribution Europe	Distribution Europe	Distribution Europe, kerosene
	tkm/kg	tkm/kg	tkm/kg	tkm/kg
Train	0.032	0.050	0.050	0.140
Truck RER	0.034	0.150	0.150	0.010
Truck CH	0.000	0.000	0.000	0.000
Barge tanker	0.047	0.100	0.100	0.100
Transoceanic tanker	0.000	0.000	0.000	0.000
Airplane	0.000	0.000	0.000	0.000
Pipeline Onshore	0.000	0.300	0.300	0.350
Total	**0.113**	**0.600**	**0.600**	**0.600**
	Jungbluth 2007 based on Shell	*Edwards et al. 2014*	*This study*	*This study*

Diesel is imported in relevant quantities to the European market while gasoline is exported (Fig. 8.1). There are so far no LCI-data for diesel production in overseas available, but the associated transports are considered.

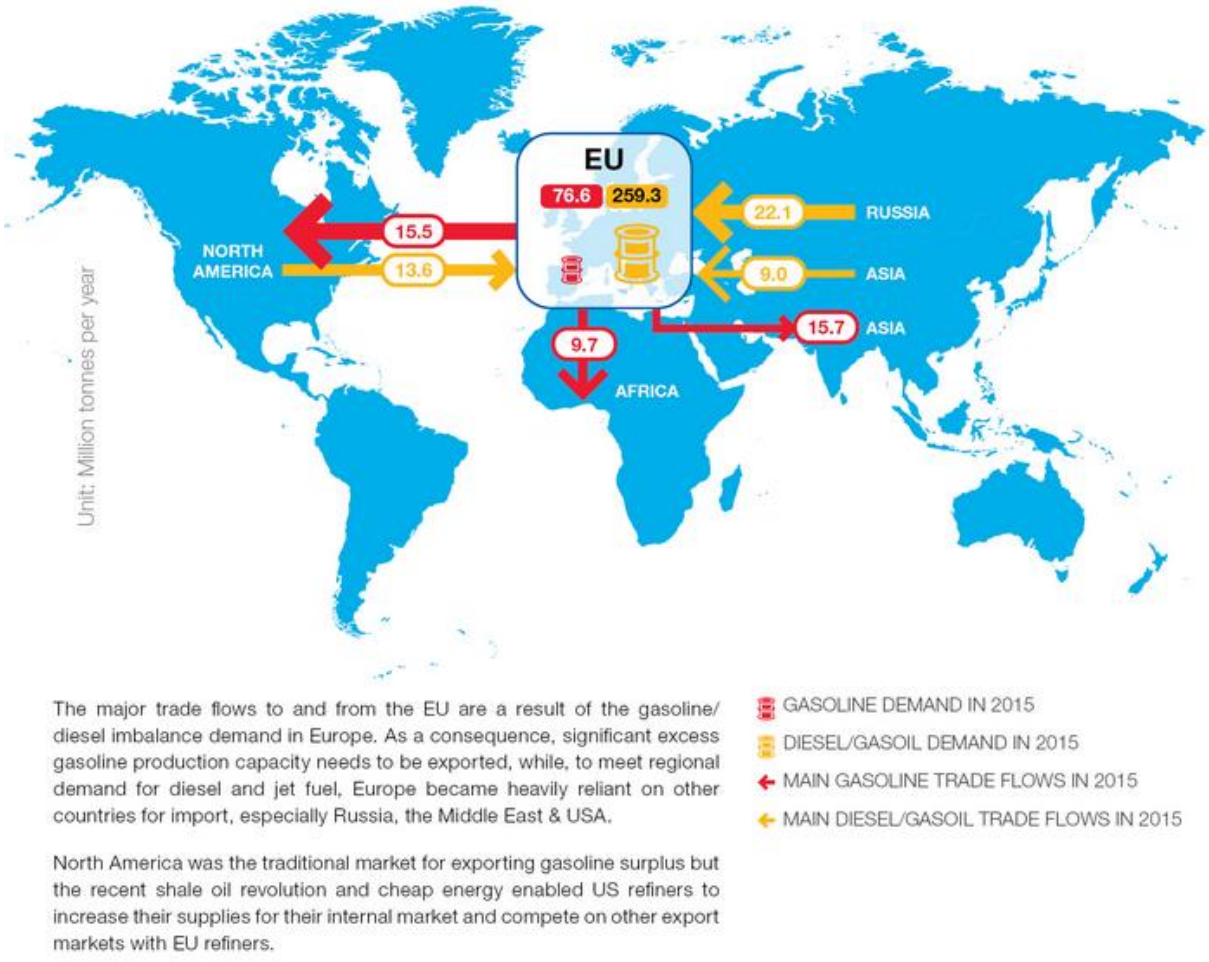

Fig. 8.1 Major gasoline and diesel trade flows to and from the EU in 2015[14]

The transports for diesel are calculated in Tab. 8.4.

In 2014, around 10% of bioethanol and around 26% of biodiesel consumed in the EU was imported. The main exporting countries were Malaysia for biodiesel and Guatemala, Bolivia, Pakistan, Russia, Peru for bioethanol (European Commission 2017).[15]

The distance for biodiesel has thus been calculated by multiplying the distance from Malaysia with 26% * 5.5% for the share of biodiesel in total.

[14] https://www.fuelseurope.eu/dataroom/static-graphs/

[15] Three of them participate in the EU Special Incentive Arrangement for Sustainable Development and Good Governance ("GSP+"). The first Report on the Generalized Scheme of Preferences for the period 2014-201529 provides an analysis of the situation on human and labor rights, environmental protection and good governance in these countries. In 2015, imports of bioethanol and biodiesel decreased with largest decrease of ethanol imports from GSP+ countries.

Tab. 8.4 Transports calculated for the import of diesel to Europe

	Pipeline	Tanker	Diesel	Diesel
	tkm/t	tkm/t	%	Mio. t
Middle East	1'400	16'792	3.5%	9
Russia	5'241	255	8.5%	22
North Africa	994	2'874	0.0%	-
North America	500	9'300	5.2%	14
Malaysia (Palm oil)		15'400	1.4%	
Total demand				259
Transports diesel	**522**	**1'321**		

Ethanol is imported mainly from overseas as shown in Fig. 8.2. Imports of bioethanol are calculated with an additional shipping distance of 10‘000 km.

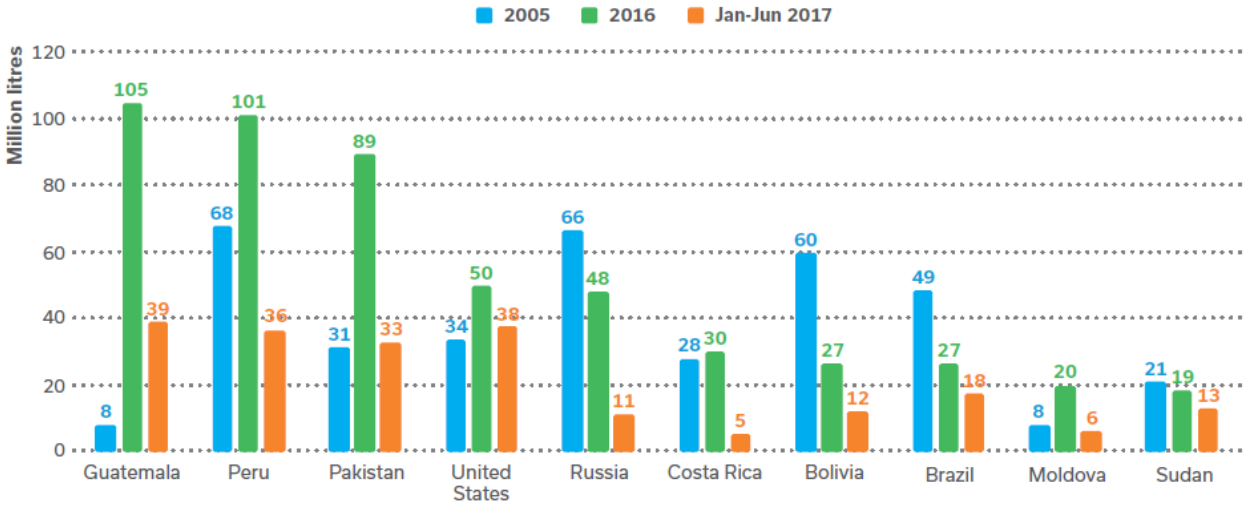

Fig. 8.2 Main countries of origin of ethanol imports into the EU[16]

Other assumptions for transport distances for the distribution of products in Europe have not been updated.

9 Summary of life cycle inventory data

In this chapter the life cycle inventories for the newly modelled and updated processes are presented. All data are provided as unit process raw data in the EcoSpold v1 format (unit process in SimaPro). The electronic data is including full EcoSpold v1 documentation.

For each investigated process, two types of tables (X-Process and X-Exchange) are provided in this report. Tab. 9.1 contains Meta-information about the newly modelled and updated processes. Tab. 9.2 until Tab. 9.4 show the full life cycle inventory data for the newly modelled and updated processes.

16 http://epure.org/media/1610/2016-industry-statistics.pdf

Tab. 9.1 Meta information for the investigated life cycle inventories, part 1

Name	petrol, two-stroke blend, at regional storage	regional distribution, oil products	petrol, at regional storage	diesel, at regional storage
Location	CH	RER	CH	CH
InfrastructureProcess	0	1	0	0
Unit	kg	unit	kg	kg
IncludedProcesses	Mixing of lubricant and petrol (ratio 1:50) at the petrol station.	Infrastructure (materials and land use) for storage tanks and petrol stations.	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.
LocalName	Benzin, Zweitakt, ab Regionallager	Regionalverteilung, Erdölprodukte	Benzin, ab Regionallager	Diesel, ab Regionallager
Synonyms			gasoline	green diesel//gasoil
GeneralComment	Rough estimation. Other mixing ratios from 1:5 up to 1:100 are possible. Energy use for mixing and additional fugitive emissions from mixing are neglected.	Bottom-Up estimation based on plant data. Life time is 40 years. Product storage volume of storage tanks is 10'000 m3. The average storage time is 2 months. Thus total through flow in the life time is 4.8 mio. m3.	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports. Considering the imports to Switzerland and share of biogenic fuels.	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports. Considering the imports to Switzerland and share of biogenic fuels.
InfrastructureIncluded	1	1	1	1
Category	oil	oil	oil	oil
SubCategory	distribution	production	distribution	distribution
LocalCategory	Erdöl	Erdöl	Erdöl	Erdöl
LocalSubCategory	Brenn- und Treibstoffe	Bereitstellung	Brenn- und Treibstoffe	Brenn- und Treibstoffe
Formula				
StatisticalClassification				
CASNumber				
StartDate	1989	1991	1989	2000
EndDate	2016	2016	2016	2016
DataValidForEntirePeriod	1	1	1	1
OtherPeriodText	Literature publication for mixing ratio and time of estimation.	Publication of literature.	Most information for the year 2000. Split up of NMVOC emissions published 1989.	Most information for the year 2000. Split up of NMVOC emissions published 1989.
Text	CH	Data for materials investigated in CH.	Surveys mainly for DE and CH.	Surveys mainly for DE and CH.
Text	Mixing of two-stroke petrol at the fuel station.	Tank storage and fuel stations.	Distribution of petroleum products.	Distribution of petroleum products.
Percent				
ProductionVolume	Not known.	In 2015 total storage capacity in Switzerland was 7.5 Mio. m3.	2442099t in 2016	2672000t in 2016
SamplingProcedure	Own estimation based on mixing ratio.	Literature and own estimations.	Environmental reports and literature.	Environmental reports and literature.
Extrapolations	none	From CH to RER.	From single companies to average data.	From single companies to average data.
UncertaintyAdjustments	none	none	none	none

Meta information for the investigated life cycle inventories, part 2

Name	kerosene, at regional storage	light fuel oil, at regional storage	heavy fuel oil, at regional storage	naphtha, at regional storage
Location	CH	CH	CH	CH
InfrastructureProcess	0	0	0	0
Unit	kg	kg	kg	kg
IncludedProcesses	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.
LocalName	Kerosin, ab Regionallager	Heizöl EL, ab Regionallager	Heizöl S, ab Regionallager	Naphtha, ab Regionallager
Synonyms			Schweröl // HFO	Benzine Petroleum Naphtha// Naphtha//
GeneralComment	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports. Considering the imports to Switzerland and share of biogenic fuels.	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports. Considering the imports to Switzerland and share of biogenic fuels.	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports. Considering the imports to Switzerland and share of biogenic fuels.	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports. Considering the imports to Switzerland and share of biogenic fuels.
InfrastructureIncluded	1	1	1	1
Category	oil	oil	oil	oil
SubCategory	distribution	distribution	distribution	distribution
LocalCategory	Erdöl	Erdöl	Erdöl	Erdöl
LocalSubCategory	Brenn- und Treibstoffe	Brenn- und Treibstoffe	Brenn- und Treibstoffe	Brenn- und Treibstoffe
Formula				
StatisticalClassification				
CASNumber				008030-30-6
StartDate	1989	1989	1989	1989
EndDate	2016	2016	2016	2016
DataValidForEntirePeriod	1	1	1	1
OtherPeriodText	Most information for the year 2000. Split up of NMVOC emissions published 1989.	Most information for the year 2000. Split up of NMVOC emissions published 1989.	Most information for the year 2000. Split up of NMVOC emissions published 1989.	Most information for the year 2000. Split up of NMVOC emissions published 1989.
Text	Surveys mainly for DE and CH.	Surveys mainly for DE and CH.	Surveys mainly for DE and CH.	Surveys mainly for DE and CH.
Text	Distribution of petroleum products.	Distribution of petroleum products.	Distribution of petroleum products.	Distribution of petroleum products.
Percent				
ProductionVolume	1715985t in 2016	2575355t in 2016	3339t in 2016	18694t in 2016
SamplingProcedure	Environmental reports and literature.	Environmental reports and literature.	Environmental reports and literature.	Environmental reports and literature.
Extrapolations	From single companies to average data.	From single companies to average data.	From single companies to average data.	From single companies to average data.
UncertaintyAdjustments	none	none	none	none

Meta information for the investigated life cycle inventories, part 3

Name	petrol, at regional storage	diesel, at regional storage	kerosene, at regional storage	light fuel oil, at regional storage
Location	RER	RER	RER	RER
InfrastructureProcess	0	0	0	0
Unit	kg	kg	kg	kg
IncludedProcesses	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.
LocalName	Benzin, ab Regionallager	Diesel, ab Regionallager	Kerosin, ab Regionallager	Heizöl EL, ab Regionallager
Synonyms	gasoline	green diesel//gasoil		
GeneralComment	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports.	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports.	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports.	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports.
InfrastructureIncluded	1	1	1	1
Category	oil	oil	oil	oil
SubCategory	distribution	distribution	distribution	distribution
LocalCategory	Erdöl	Erdöl	Erdöl	Erdöl
LocalSubCategory	Brenn- und Treibstoffe	Brenn- und Treibstoffe	Brenn- und Treibstoffe	Brenn- und Treibstoffe
Formula				
StatisticalClassification				
CASNumber				
StartDate	1989	2000	1989	1989
EndDate	2016	2016	2016	2016
DataValidForEntirePeriod	1	1	1	1
OtherPeriodText	Most information for the year 2000. Split up of NMVOC emissions published 1989.	Most information for the year 2000. Split up of NMVOC emissions published 1989.	Most information for the year 2000. Split up of NMVOC emissions published 1989.	Most information for the year 2000. Split up of NMVOC emissions published 1989.
Text	Surveys mainly for DE and CH.	Surveys mainly for DE and CH.	Surveys mainly for DE and CH.	Surveys mainly for DE and CH.
Text	Distribution of petroleum products.	Distribution of petroleum products.	Distribution of petroleum products.	Distribution of petroleum products.
Percent				
ProductionVolume	Not known	258 billion t in 2000	47 billion t in 2000	Not known
SamplingProcedure	Environmental reports and literature.	Environmental reports and literature.	Environmental reports and literature.	Environmental reports and literature.
Extrapolations	From single companies to average data.	From single companies to average data.	From single companies to average data.	From single companies to average data.
UncertaintyAdjustments	none	none	none	none

Meta information for the investigated life cycle inventories, part 4

Name	heavy fuel oil, at regional storage	naphtha, at regional storage	ethanol, 99.7% in H2O, from biomass, at distillation	methyl ester, from biogenic oils, mix, at regional storage
Location	RER	RER	RER	RER
InfrastructureProcess	0	0	0	0
Unit	kg	kg	kg	kg
IncludedProcesses	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.	Transportation of product from the refinery to the end user. Operation of storage tanks and petrol stations. Emissions from evaporation and treatment of effluents. Excluding emissions from car-washing at petrol stations.	This dataset includes the dehydration of hydrated ethanol (95%) to anhydrous ethanol (99.7%). Hydrated ethanol input is modelled for the present European ethanol consumption mix. Treatment of waste streams is included.	This dataset includes the mix of methyl ester used as biofuels for the European supply mix.
LocalName	Heizöl S, ab Regionallager	Naphtha, ab Regionallager	Ethanol, 99.7% in H2O, aus Biomasse, ab Destillation	Methylester, aus biogenen Ölen, Mix, ab Lager
Synonyms	Schweröl // HFO	Benzine Petroleum Naphtha// Naphtha// Naphtha, coal tar// Petroleum Benzine// rubber solvent// VM&P naphtha	Alkohol// alcohol dehydrated// algrain// Anhydrol// cologne spirit// cologne spirits (alcohol)// Denatured alcohol// Ethyl alcohol// Ethanol// ethanol 200 proof// Ethanol absolute// ethyl hydrate// ethyl hydroxide// fermentation alcohol// grain alcohol// bioethanol// bio-ethanol	0
GeneralComment	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports.	Inventory for the distribution of petroleum product to the final consumer (household, car, power plant, etc.) including all necessary transports.	Inventory refers to the production of 1 kg anhydrous ethanol 99.7% (dry basis, i.e. 1.003 kg anhydrous ethanol wet basis). Dehydration is carried out by molecular sieve technology. Ethanol is produced from rye, in the average RER context.	Inventory refers to 1 kg biodiesel used as transport fuel for blending of diesel.
InfrastructureIncluded	1	1	1	1
Category	oil	oil	biomass	biomass
SubCategory	distribution	distribution	fuels	fuels
LocalCategory	Erdöl	Erdöl	Biomasse	Biomasse
LocalSubCategory	Brenn- und Treibstoffe	Brenn- und Treibstoffe	Brenn- und Treibstoffe	Brenn- und Treibstoffe
StartDate	1989	1989	2002	2014
EndDate	2016	2016	2016	2016
DataValidForEntirePeriod	1	1	1	1
OtherPeriodText	Most information for the year 2000. Split up of NMVOC emissions published 1989.	Most information for the year 2000. Split up of NMVOC emissions published 1989.	Data from 2002 to 2006, current technology for the production of ethanol from starch-based feedstocks	Data for the supply mix in 2014.
Text	Surveys mainly for DE and CH.	Surveys mainly for DE and CH.	Data is from the etha+ project (Alcosuisse, CH), adapted to RER context	Europe
Text	Distribution of petroleum products.	Distribution of petroleum products.	Dehydration is done by molecular sieve technology.	No technology modelled
Percent				
ProductionVolume	123 billion t in 2000	123 billion t in 2000	1.2 Mio tonnes	2.1 Mio tonnes
SamplingProcedure	Environmental reports and literature.	Environmental reports and literature.	Statistical data published by the European Commission.	Statistical data published by the European Commission.
Extrapolations	From single companies to average data.	From single companies to average data.	none	none
UncertaintyAdjustments	none	none	none	none

Tab. 9.3 and Tab. 9.4 show the modelled unit process raw data for the distribution of mineral oil products.

The unit process raw data for two-stroke blend in Tab. 9.2 have not been updated as this was not commissioned for this project. Lubricating oil and petrol are mixed in a ratio 1:50.

Tab. 9.2 Unit process raw data of two-stroke blends

	Name	Location	InfrastructureProcess	Unit	*petrol, two-stroke blend, at regional storage*	*petrol, two-stroke blend, at regional storage*	UncertaintyType	StandardDeviation95 %	GeneralComment
	Location				*CH*	*RER*			
	InfrastructureProcess				*0*	*0*			
	Unit				*kg*	*kg*			
technosphere	lubricating oil, at plant	RER	0	kg	2.00E-2	2.00E-2	1	1.53	(3,3,5,1,1,na); Literature
	transport, lorry >16t, fleet average	RER	0	tkm	2.00E-3	2.00E-3	1	2.38	(4,5,5,5,3,na); Standard distance 100 km
	petrol, at regional storage	CH	0	kg	9.80E-1	0	1	1.53	(3,3,5,1,1,na); Assumption
	petrol, at regional storage	RER	0	kg	0	9.80E-1	1	1.53	(3,3,5,1,1,na); Assumption

Tab. 9.3 Unit process raw data of the distribution of mineral oil products to the Swiss final consumer, part 1

	Name	Location	Infrastructur	Unit	*petrol, at regional storage*	*diesel, at regional storage*	*kerosene, at regional storage*	*light fuel oil, at regional storage*	*heavy fuel oil, at regional storage*	*naphtha, at regional storage*	Uncertainty	StandardDeviation95%	GeneralComment	Eidgenössische Zollverwaltung	Erdöl-Vereinigung	Rohstoffe Biogene Treibstoffe	Share at filling station	Biogenic carbon content
	Location				*CH*	*CH*	*CH*	*CH*	*CH*	*CH*				*CH*	*CH*	*CH*	*CH*	*GLO*
	InfrastructureProcess				*0*	*0*	*0*	*0*	*0*	*0*				*2016*	*2016*	*2016*	*2016*	*2016*
	Unit				*kg*	*kg*	*kg*	*kg*	*kg*	*kg*				*m3*	*t*	*%*	*%*	*kg CO2-eq*
oil products	petrol, at refinery	CH	0	kg	29%	-	-	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016	2'814'240	723'267		28.74%	0
	petrol, at refinery	RER	0	kg	68%	-	-	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016	104'210	1'718'832		68.29%	0
	ethanol, 99.7% in H2O, from biomass, at distillation	CH	0	kg	0.00%	-	-	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016	-			0.00%	1.907
	ethanol, 99.7% in H2O, from wood, at distillation	SE	0	kg	0.22%	-	-	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016, wood waste	38'278	27290	20.28%	0.22%	1.907
	ethanol, 99.7% in H2O, from sugarcane molasses, at distillation	BR	0	kg	0.87%	-	-	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016, pentosane and trester			79.72%	0.86%	1.907
	methyl tert-butyl ether, at plant	RER	0	kg	1.89%	-	-	-	-	-	1	1.07	(1,1,1,1,1,na); Data of Swiss refinery 6.7%		47'624		1.89%	0
	diesel, at refinery	CH	0	kg	-	32%	-	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016	2'966'093	873'672		31.85%	0
	diesel, at refinery	RER	0	kg	-	66%	-	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016	98'209	1'798'328		65.56%	0
	vegetable oil methyl ester, at esterification plant	CH	0	kg	-	0.28%	-	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016	7'948	7'787		0.28%	2.83
	vegetable oil methyl ester, at esterification plant	FR	0	kg	-	2.30%	-	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016	64'357	63'051		2.30%	2.83
	kerosene, at refinery	CH	0	kg	-	-	3%	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016		45'165		2.63%	0
	kerosene, at refinery	RER	0	kg	-	-	97%	-	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016		1'670'820		97.37%	0
	light fuel oil, at refinery	CH	0	kg	-	-	-	32%	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016		819'022		31.80%	
	light fuel oil, at refinery	RER	0	kg	-	-	-	68%	-	-	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016		1'756'333		68.20%	
	heavy fuel oil, at refinery	CH	0	kg	-	-	-	-	83%		1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016		2'770		82.96%	
	heavy fuel oil, at refinery	RER	0	kg	-	-	-	-	17%		1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016		569		17.04%	
	naphtha, at refinery	CH	0	kg	-	-	-	-	-	28%	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016		5'151		27.55%	
	naphtha, at refinery	RER	0	kg	-	-	-	-	-	72%	1	1.07	(1,1,1,1,1,na); Statistics (EV and EZV) 2016		13'543		72.45%	
energy use	electricity, low voltage, at grid	CH	0	kWh	5.08E-2	6.70E-3	5.08E-2	5.08E-2	5.08E-2	5.08E-2	1	1.51	(2,1,5,3,1,na); Literature fuel depot plus dispensing at retail site					
	light fuel oil, burned in boiler 100kW, average	CH	0	MJ	6.25E-4	6.25E-4	6.25E-4	-	-	-	1	1.25	(2,4,4,3,1,na); Environmental report					
water	tap water, unspecified natural origin CH, at user	CH	0	kg	6.89E-4	6.89E-4	6.89E-4	6.89E-4	6.89E-4	6.89E-4	1	1.17	(2,4,3,3,1,na); Environmental report					
transports	transport, lorry 20-28t, fleet average	CH	0	tkm	5.01E-2	5.01E-2	1.00E-3	5.01E-2	5.01E-2	5.01E-2	1	2.02	(3,2,1,1,1,na); Estimation based on statistics					
	transport, lorry >16t, fleet average	RER	0	tkm	3.05E-2	2.98E-2	4.28E-2	3.00E-2	7.49E-3	3.18E-2	1	2.02	(3,2,1,1,1,na); Estimation based on statistics					
	transport, freight, rail	RER	0	tkm	2.25E-1	2.21E-1	3.04E-1	2.22E-1	7.79E-2	2.34E-1	1	2.02	(3,2,1,1,1,na); Estimation based on statistics					
	Losses			kg	1.20E-3	1.11E-4	7.50E-5	1.27E-5	1.27E-5	1.27E-5								
	Total share imports	RER		kg	69%	68%	97%	68%	17%	72%								
	Carbon content			kg	0.865	0.865	0.850	0.862	0.875	0.404								
	Biogenic carbon share			%	0.7%	2.3%	0.0%	0.0%	0.0%	0.0%								

Unit process raw data of the distribution of mineral oil products to the Swiss final consumer, including amount of distributed products in CH 2016, part 2

	Name	Location	Infrastructur	Unit	*petrol, at regional storage*	*diesel, at regional storage*	*kerosene, at regional storage*	*light fuel oil, at regional storage*	*heavy fuel oil, at regional storage*	*naphtha, at regional storage*	Uncertainty	StandardDeviation95%	GeneralComment	Eidgenössische Zollverwaltung	Erdöl-Vereinigung	Rohstoffe Biogene Treibstoffe	Share at filling station	Biogenic carbon content
	Location				*CH*	*CH*	*CH*	*CH*	*CH*	*CH*				*CH*	*CH*	*CH*	*CH*	*GLO*
	InfrastructureProcess				*0*	*0*	*0*	*0*	*0*	*0*				*2016*	*2016*	*2016*	*2016*	*2016*
	Unit				*kg*	*kg*	*kg*	*kg*	*kg*	*kg*				*m3*	*t*	*%*	*%*	*kg CO2-eq*
	petrol, at regional storage	CH	0	kg	1.00E+0	-	-	-	-	-					2'442'099			
	diesel, at regional storage	CH	0	kg	-	1.00E+0	-	-	-	-					2'672'000			
	kerosene, at regional storage	CH	0	kg	-	-	1.00E+0	-	-	-					1'715'985			
	light fuel oil, at regional storage	CH	0	kg	-	-	-	1.00E+0	-	-					2'575'355			
	heavy fuel oil, at regional storage	CH	0	kg	-	-	-	-	1.00E+0	-					3'339			
	naphtha, at regional storage	CH	0	kg	-	-	-	-	-	1.00E+0					18'694			
	transport, barge tanker	RER	0	tkm	1.83E-1	1.79E-1	2.56E-1	1.79E-1	4.48E-2	1.91E-1	1	2.02	(3,2,1,1,1,na); Estimation based on statistics					
	transport, crude oil pipeline, onshore	RER	0	tkm	4.77E-2	4.01E-1	6.88E-2	4.68E-2	1.17E-2	4.97E-2	1	1.13	(3,2,1,1,1,na); Estimation based on statistics					
	transport, transoceanic tanker	OCE	0	tkm	2.29E-2	8.91E-1	-	-	-	-	1	2.00	(1,1,1,1,1,na); Imports from outside Europe					
infrastructure	regional distribution, oil products	RER	1	unit	5.54E-10	5.46E-10	2.08E-10	2.08E-10	2.08E-10	2.08E-10	1	3.24	(3,na,5,3,1,na); Calculation					
wastes	treatment, sewage, to wastewater treatment, class 2	CH	0	m3	6.89E-7	6.89E-7	6.89E-7	6.89E-7	6.89E-7	6.89E-7	1	1.25	(2,4,4,3,1,na); Used water					
	treatment, rainwater mineral oil storage, to wastewater treatment, class 2	CH	0	m3	7.50E-5	7.50E-5	5.00E-5	5.00E-5	5.00E-5	5.00E-5	1	1.38	(4,5,4,3,1,na); Rainwater with pollutants					
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg	6.27E-6	6.27E-6	6.27E-6	6.27E-6	6.27E-6	6.27E-6	1	1.25	(2,4,4,3,1,na); Environmental report					
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH	0	kg	1.68E-4	1.68E-4	1.85E-5	1.85E-5	1.85E-5	1.85E-5	1	1.25	(2,4,4,3,1,na); Environmental report and literature					
air emissions	Heat, waste	-	-	MJ	1.83E-1	2.41E-2	1.83E-1	1.83E-1	1.83E-1	1.83E-1	1	1.51	(2,1,5,1,1,na); Calculation					
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.58E-4	-	-	-	-	-	1	1.54	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	8.28E-5	-	-	-	-	-	1	1.54	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	Hydrocarbons, aromatic	-	-	kg	1.20E-5	-	-	-	-	-	1	1.54	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	Benzene	-	-	kg	1.20E-5	-	-	-	-	-	1	3.03	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	Methane, fossil	-	-	kg	3.60E-7	-	-	-	-	-	1	1.54	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	t-Butyl methyl ether	-	-	kg	6.00E-5	-	-	-	-	-	1	1.54	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	Toluene	-	-	kg	2.40E-5	-	-	-	-	-	1	1.54	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	Xylene	-	-	kg	9.60E-6	-	-	-	-	-	1	1.54	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	Benzene, ethyl-	-	-	kg	2.52E-5	-	-	-	-	-	1	3.03	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	Hexane	-	-	kg	1.56E-5	-	-	-	-	-	1	1.54	(2,4,3,3,1,na); Winkler 2004 with VOC from Env. Report					
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg		1.11E-4	7.50E-5	1.27E-5	1.27E-5	1.27E-5	1	1.54	(2,4,3,3,1,na); Winkler 2004					
	Carbon dioxide, fossil	-	-	kg	-3.41E-2	-8.14E-2	-	-	-	-	1	1.12	(3,1,1,1,1,na); Credit for fossil fuel replaced by biogenic fuel					
	Carbon dioxide, biogenic	-	-	kg	2.07E-2	7.32E-2	-	-	-	-	1	1.12	(3,1,1,1,1,na); Emission from biogenic fuel					
	Losses			kg	1.20E-3	1.11E-4	7.50E-5	1.27E-5	1.27E-5	1.27E-5								
	Total share imports	RER		kg	69%	68%	97%	68%	17%	72%								
	Carbon content			kg	0.865	0.865	0.850	0.862	0.875	0.404								
	Biogenic carbon share			%	0.7%	2.3%	0.0%	0.0%	0.0%	0.0%								

Tab. 9.4 Unit process raw data of the distribution of mineral oil products to the European final consumer, part 1

	Name	Location	InfrastructureProcess	Unit	*petrol, at regional storage*	*diesel, at regional storage*	*kerosene, at regional storage*	*light fuel oil, at regional storage*	*heavy fuel oil, at regional storage*	*naphtha, at regional storage*	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				*RER*	*RER*	*RER*	*RER*	*RER*	*RER*			
	InfrastructureProcess				*0*	*0*	*0*	*0*	*0*	*0*			
	Unit				*kg*	*kg*	*kg*	*kg*	*kg*	*kg*			
technosphere	ethanol, 99.7% in H2O, from biomass, at distillation	RER	0	kg	3.23E-2	-	-	-	-	-	1	1.07	(1,1,1,1,1,1); Consumption mix of ethanol
	petrol, at refinery	RER	0	kg	9.48E-1	-	-	-	-	-	1	1.07	(1,1,1,1,1,1); Statistics
	methyl tert-butyl ether, at plant	RER	0	kg	2.10E-2	-	-	-	-	-	1	1.07	(1,1,1,1,1,1); Statistics
	methyl ester, from biogenic oils, mix, at regional storage	RER	0	kg	-	5.50E-2	-	-	-	-	1	1.07	(1,1,1,1,1,1); Consumption mix of methyl ester
	diesel, at refinery	RER	0	kg	-	9.45E-1	-	-	-	-	1	1.07	(1,1,1,1,1,1); Calculation incl. Losses
	kerosene, at refinery	RER	0	kg	-	-	1.00E+0	-	-	-	1	1.07	(1,1,1,1,1,1); Calculation incl. Losses
	light fuel oil, at refinery	RER	0	kg	-	-	-	1.00E+0	-	-	1	1.07	(1,1,1,1,1,1); Calculation incl. Losses
	heavy fuel oil, at refinery	RER	0	kg	-	-	-	-	1.00E+0	-	1	1.07	(1,1,1,1,1,1); Calculation incl. Losses
	naphtha, at refinery	RER	0	kg	-	-	-	-	-	1.00E+0	1	1.07	(1,1,1,1,1,1); Calculation incl. Losses
	electricity, low voltage, production ENTSO, at grid	ENTSO	0	kWh	5.08E-2	5.08E-2	5.08E-2	5.08E-2	5.08E-2	5.08E-2	1	1.52	(2,1,5,1,1,3); Literature fuel depot plus dispensing at retail site
	light fuel oil, burned in boiler 100kW, average	CH	0	MJ	6.25E-4	6.25E-4	6.25E-4	-	-	-	1	1.26	(2,4,4,3,1,3); Environmental report
	tap water, unspecified natural origin RER, at user	RER	0	kg	6.89E-4	6.89E-4	6.89E-4	6.89E-4	6.89E-4	6.89E-4	1	1.18	(2,4,3,3,1,3); Environmental report
	transport, lorry >16t, fleet average	RER	0	tkm	1.50E-1	1.50E-1	1.00E-2	1.50E-1	1.50E-1	1.50E-1	1	2.01	(2,1,1,1,1,3); Literature
	transport, freight, rail	RER	0	tkm	5.00E-2	5.00E-2	1.40E-1	5.00E-2	5.00E-2	5.00E-2	1	2.01	(2,1,1,1,1,3); Literature
	transport, barge tanker	RER	0	tkm	1.00E-1	1.00E-1	1.00E-1	1.00E-1	1.00E-1	1.00E-1	1	2.01	(2,1,1,1,1,3); Literature
	transport, crude oil pipeline, onshore	RER	0	tkm	3.00E-1	8.22E-1	3.50E-1	3.00E-1	3.00E-1	3.00E-1	1	1.10	(2,1,1,1,1,3); Literature
	transport, transoceanic tanker	OCE	0	tkm	3.30E-2	1.31E+0	-	-	-	-	1	2.01	(1,1,1,1,1,3); Imports from outside Europe
	regional distribution, oil products	RER	1	unit	5.54E-10	5.46E-10	2.08E-10	2.08E-10	2.08E-10	2.08E-10	1	3.24	(3,na,5,3,1,na); Calculation
	treatment, sewage, to wastewater treatment, class 2	CH	0	m3	6.89E-7	6.89E-7	6.89E-7	6.89E-7	6.89E-7	6.89E-7	1	1.26	(2,4,4,3,1,3); Used water
	treatment, rainwater mineral oil storage, to wastewater treatment, class 2	CH	0	m3	7.50E-5	7.50E-5	5.00E-5	5.00E-5	5.00E-5	5.00E-5	1	1.38	(4,5,4,3,1,na); Rainwater with pollutants
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg	6.27E-6	6.27E-6	6.27E-6	6.27E-6	6.27E-6	6.27E-6	1	1.26	(2,4,4,3,1,3); Environmental report
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH	0	kg	1.68E-4	1.68E-4	1.85E-5	1.85E-5	1.85E-5	1.85E-5	1	1.26	(2,4,4,3,1,3); Environmental report and literature
air emissions	Heat, waste	-	-	MJ	1.83E-1	1.83E-1	1.83E-1	1.83E-1	1.83E-1	1.83E-1	1	1.52	(2,1,5,1,1,3); Calculation
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.58E-4	-	-	-	-	-	1	1.55	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	8.28E-5	-	-	-	-	-	1	1.55	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	Hydrocarbons, aromatic	-	-	kg	1.20E-5	-	-	-	-	-	1	1.55	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	Benzene	-	-	kg	1.20E-5	-	-	-	-	-	1	3.04	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	Methane, fossil	-	-	kg	3.60E-7	-	-	-	-	-	1	1.55	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	t-Butyl methyl ether	-	-	kg	6.00E-5	-	-	-	-	-	1	1.55	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	Toluene	-	-	kg	2.40E-5	-	-	-	-	-	1	1.55	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	Xylene	-	-	kg	9.60E-6	-	-	-	-	-	1	1.55	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	Benzene, ethyl-	-	-	kg	2.52E-5	-	-	-	-	-	1	3.04	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	Hexane	-	-	kg	1.56E-5	-	-	-	-	-	1	1.55	(2,4,3,3,1,3); Winkler 2004 with VOC from Env. Report
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	-	1.11E-4	7.50E-5	1.27E-5	1.27E-5	1.27E-5	1	1.55	(2,4,3,3,1,3); Winkler 2004
	Carbon dioxide, fossil	-	-	kg	-1.02E-1	-1.73E-1	-	-	-	-	1	1.12	(3,1,1,1,1,1); Credit for fossil fuel replaced by biogenic fuel
	Carbon dioxide, biogenic	-	-	kg	6.17E-2	1.56E-1	-	-	-	-	1	1.12	(3,1,1,1,1,1); Emission from biogenic fuel
	Losses			kg	1.20E-3	1.11E-4	7.50E-5	1.27E-5	1.27E-5	1.27E-5			
	Carbon content			kg	0.865	0.865	0.850	0.862	0.875	0.404			
	Biogenic carbon share			%	1.9%	4.9%	0.0%	0.0%	0.0%	0.0%			

Unit process raw data of the distribution of mineral oil products to the European final consumer, part 2

	Name	Location	InfrastructureProcess	Unit	*Shares biofuel/ conventional*	*Mix, this study*	Biogenic carbon content	regional distribution	*Total, distribution Shell*	*oil products main storage, Shell*	*oil products fuel stations, Shell*	*distribution petrol*	*distribution diesel*	*distribution kerosene*	*distribution fuel oil*
	Location				*RER*	*RER*	*GLO*	*RER*	*RER*	*RER*	*RER*	*DE*	*DE*	*DE*	*DE*
	InfrastructureProcess				*2016*	*2016*	*2016*	*2014*	*0*	*0*	*0*				
	Unit				*%*	*%*	*kg CO2-eq*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*
technosphere	ethanol, 99.7% in H2O, from biomass, at distillation	RER	0	kg	3.3%	3.23%	1.91E+0								
	petrol, at refinery	RER	0	kg	96.7%	94.67%	-								
	methyl tert-butyl ether, at plant	RER	0	kg	2.10%	2.10%	-								
	methyl ester, from biogenic oils, mix, at regional storage	RER	0	kg	5.5%	5.50%	2.83E+0								
	diesel, at refinery	RER	0	kg	94.5%	94.50%	-								
	kerosene, at refinery	RER	0	kg			-								
	light fuel oil, at refinery	RER	0	kg			-								
	heavy fuel oil, at refinery	RER	0	kg			-								
	naphtha, at refinery	RER	0	kg			-								
	electricity, low voltage, production ENTSO, at grid	ENTSO	0	kWh				5.08E-2	6.70E-3	9.49E-4	5.75E-3				
	light fuel oil, burned in boiler 100kW, average	CH	0	MJ					6.25E-4	6.25E-4					
	tap water, unspecified natural origin RER, at user	RER	0	kg					6.89E-4	6.89E-4					
	transport, lorry >16t, fleet average	RER	0	tkm				1.50E-1	3.37E-2		3.37E-2				
	transport, freight, rail	RER	0	tkm				5.00E-2	3.20E-2		3.20E-2				
	transport, barge tanker	RER	0	tkm				1.00E-1	4.70E-2		4.70E-2				
	transport, crude oil pipeline, onshore	RER	0	tkm				3.00E-1			3.17E-1				
	transport, transoceanic tanker	OCE	0	tkm											
	regional distribution, oil products	RER	1	unit					-						
	treatment, sewage, to wastewater treatment, class 2	CH	0	m3					6.89E-7	6.89E-7					
	treatment, rainwater mineral oil storage, to wastewater treatment, class 2	CH	0	m3											
	disposal, municipal solid waste, 22.9% water, to sanitary landfill	CH	0	kg					6.27E-6	6.27E-6					
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH	0	kg					1.85E-5	1.85E-5					
air emissions	Heat, waste	-	-	MJ					-						
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg											
	Hydrocarbons, aliphatic, unsaturated	-	-	kg					-						
	Hydrocarbons, aromatic	-	-	kg					-						
	Benzene	-	-	kg					-						
	Methane, fossil	-	-	kg					-						
	t-Butyl methyl ether	-	-	kg					-						
	Toluene	-	-	kg					-						
	Xylene	-	-	kg					-						
	Benzene, ethyl-	-	-	kg					-						
	Hexane	-	-	kg					-						
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg				1.20E-3	4.90E-4	2.02E-4	2.89E-4	3.80E-04	1.11E-04	7.50E-05	1.27E-05
	Carbon dioxide, fossil	-	-	kg											
	Carbon dioxide, biogenic	-	-	kg											
	Publication				This study	This study	Jungbluth et al. 2007	Edwards et al 2014	Shell 2000	Shell 2000	Shell 2000	Winkler 2004	Winkler 2004	Winkler 2004	Winkler 2004

10 Datasets to be replaced in v2.2

The heating values and carbon contents of fuels have been updated during this project. The data are documented in the product properties as described in the report for refineries. In principle it is necessary to update this information whenever the use of fuels is calculated by the heating value or CO_2-emissions of burning the fuels are considered in a unit process.

Some dataset names used in the former version v2.2 are not adequate anymore. There is no leaded petrol on the market and thus "unleaded" does not have to be specified. Also, today all European products have low-sulphur content. Therefore, the following replacements should be made for older inventories.

- diesel, low-sulphur -→ diesel (replace)
- petrol, unleaded → petrol (replace)
- petrol, low-sulphur → petrol (change name)

11 Data quality

All information relevant for the impact assessment with 3 LCIA indicators has been checked and updated during this project.

A major uncertainty is due to the underlying data for biofuels blended in the petrol and diesel distributed for the use in transport processes. LCI data were not available for all types of biomass feedstocks and locations. It is known that there might be large differences between different production pathways and thus it would be recommended to investigate new LCI for the biofuel production pathways relevant for the Swiss and European market (e.g. based on Muñoz et al. 2014).

The following pathways relevant from the Swiss market should be newly investigated:

- ethanol, grape marc, IT
- ethanol, from pentosane or starch, NL
- biodiesel, glycerine
- biodiesel, animal fat, CH and RER
- biodiesel, free fatty acids (FFA)
- hydrogenated or hydro treated vegetable oils (HVO)

For the European market the following pathway should be investigated in addition to the Swiss pathways:

- ethanol, wheat
- ethanol, barley
- biodiesel, sunflower

The data quality would also be improved if more specific data for refinery operation in Germany and products imported from Germany to Switzerland would be investigated. This is because half of the mineral oil products used in Switzerland are imported from Germany.

Some older information is not updated but of minor relevance for the key LCIA indicators used for the quality checks. No new information was considered for:

- Infrastructure
- VOC profile of emissions
- Emissions to water
- Wastes

The module is complete in terms of environmental impacts. However, possible accidents and incidents could not be considered or accounted for due to a lack of data.

There is also a lack of newer information on the operation of petrol stations (waste water from petrol stations). There are influences from other types of business e.g. from carwashes, shops and the like which in principle should not be attributed to the distribution of the fuels. Thus, a thorough investigation of all inputs and outputs used directly at the filling station is difficult.

The information on waste water contents is averaged based on two case studies and is turned into freight rates with rainfall levels customary in Switzerland. Tank cleaning sludges are processed and delivered to the cement plants as substitute fuel. Accordingly, there is no need to balance the preparation steps.

Although storage and regional transport is simple in terms of processes, the large number of suppliers makes it difficult to keep track of actual transport movements. Thus, also some estimations had to be made regarding distances and transhipment activities which are now at least in line with assessments made by the mineral oil industry.

The information is mainly provided by oil companies (logistics) or governmental agencies (water protection and disposal aspects). The information can be regarded as reliable, but in terms of product distribution strategy it only reflects the situation of a company. Some of the data used is already outdated. This applies, for example, to the uncertain data on pollutant concentration.

12 Life cycle impact assessment

Tab. 12.1 shows the key indicator results for the processes which have been updated in this project. The LCIA calculation is made from cradle to filling station (or storage).

The input of the fuel from refinery is the most dominant contributor for all three main indicators investigated in this study. Also, the biofuels used for blending are very relevant for the results calculated for the total impacts of supplying transport fuels. Second most important are transports from refinery to the regional distribution centre. Direct emissions, energy uses, and infrastructure are normally of minor importance for the datasets investigated in this chapter.

Tab. 12.1 Key indicator results for the updated processes investigating the distribution of Swiss and European mineral oil products and lower heating value assumed in this study. (red marks highest and green lowest values *per column* of special interest)

Refinery products	reference value	primary energy factor, total	primary energy factor,fossil	primary energy factor, nuklear	primary energy factor, renewable	CO2 equivalents	eco-points	primary energy factor,fossil	Lower heating value
		MJ-eq	MJ-eq	MJ-eq	MJ-eq	kg CO2-eq	eco-points 2013	MJ-eq/MJ	MJ-eq/kg
diesel/CH	kg	54.8	53.8	0.74	0.25	0.79	1'312	1.25	43.0
diesel/RER	kg	56.6	53.1	0.96	2.34	0.79	1'587	1.24	43.0
heavy fuel oil/CH	kg	52.8	51.5	1.03	0.29	0.77	1'256	1.25	41.2
heavy fuel oil/RER	kg	52.5	51.4	0.84	0.28	0.76	1'209	1.25	41.2
kerosene/CH	kg	55.9	54.5	1.02	0.32	0.84	1'306	1.26	43.2
kerosene/RER	kg	55.7	54.6	0.80	0.27	0.85	1'292	1.26	43.2
light fuel oil/CH	kg	55.8	54.4	1.03	0.31	0.85	1'327	1.27	42.9
light fuel oil/RER	kg	55.7	54.6	0.82	0.28	0.86	1'308	1.27	42.9
naphtha/CH	kg	57.7	56.1	1.27	0.37	0.83	1'361	1.25	45.0
naphtha/RER	kg	57.5	56.2	1.03	0.34	0.84	1'341	1.25	45.0
petrol/CH	kg	56.9	54.5	1.28	1.08	0.88	1'412	1.28	42.6
petrol/RER	kg	57.1	54.1	1.09	1.85	0.86	1'546	1.27	42.6

Tab. 12.2 shows the change of results compared to the former version of the database. There is a significant increase of the global warming potential and total environmental impacts. This is due to the updates made in the upstream and downstream processes (Jungbluth et al. 2018; Meili & Jungbluth 2018) and the introduction of biofuels with the credit given here for the inventory on distribution (see chapter 5.2 for further explanation). The CED did not change to a large extend, but there are very large changes in the sub-category on renewable energy due to the introduction of biofuels. There is some deviation in the results for the ecological scarcity 2013.

Tab. 12.2 Relative increase or decrease of results compared to the KBOB database (red marks highest relative *overall* increases and green marks relative *overall* decreases)

Increase or decrease of indicator results compared to KBOB database	primary energy factor, total [MJ-eq]	primary energy factor,fossil [MJ-eq]	primary energy factor, nuklear [MJ-eq]	primary energy factor, renewable [MJ-eq]	CO2 equivalents [kg CO2-eq]	eco-points [eco-points 2013]
diesel/CH	-0.3%	-1.0%	45.9%	73.9%	23.7%	-0.3%
diesel/RER	1.9%	-3.2%	92.3%	1485.4%	21.9%	8.3%
heavy fuel oil/CH	-0.8%	-2.1%	99.7%	110.5%	39.5%	12.1%
heavy fuel oil/RER	-3.0%	-3.9%	64.9%	89.7%	33.0%	-12.7%
kerosene/CH	0.9%	-0.4%	99.5%	116.8%	28.5%	-10.7%
kerosene/RER	1.3%	0.4%	68.3%	96.4%	34.3%	-10.4%
light fuel oil/CH	1.4%	0.2%	101.4%	116.9%	33.5%	-2.4%
light fuel oil/RER	1.0%	0.1%	67.2%	94.5%	36.1%	-9.6%
naphtha/CH	8.0%	6.5%	106.7%	134.8%	52.9%	19.8%
naphtha/RER	6.2%	5.1%	72.7%	95.9%	47.3%	-3.8%
petrol/CH	-1.1%	-3.7%	82.6%	462.3%	8.4%	-5.4%
petrol/RER	-2.3%	-6.0%	62.7%	850.4%	0.7%	-7.8%

13 Outlook

The Swiss law on air pollution control (LRV) will in future also allow the use of biofuels in small heating systems. Thus, it can be expected that biofuels will enter this market as well in the future. This should be evaluated in the next update of these data.

The same holds true for the aviation industry, which is presently discussing the introduction of biofuels like ethanol. Thus, also the kerosene mix might have to be adapted in the future.

MTBE is an important input for petrol. A verification and update of the production data would be recommended in near future.

Furhtermore it would be recommended to record the input of all aditives in the datasets for distribution instead of the datasets for the refinery process as this would facilitate the update.

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