

Life cycle inventories of plastics

Report

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Abbreviations

AOX	Adsorbable Organic Halogen
BAFU:2024	Life Cycle Inventory database of the Swiss Federal Administration that is used as a starting database where the plastic data is implemented into
BOD	Biochemical Oxygen Demand
BOD5	Biochemical oxygen demand for 5 days of microbial degradation
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CFC	Hydrocarbons, fully chlorinated, fluorinated
CH ₄	Methane
CO	Carbon monoxide
CO ₂	Carbon dioxide
COD	Chemical Oxygen Demand
DOC	Dissolved Organic Carbon
E-PVC	Emulsion Polyvinyl Chloride
FOEN	Federal Office for the Environment
GWP	Global Warming Potential
HDPE	High-Density Polyethylene
IFEU	Institute for Energy and Environmental Research
IPCC	International Panel on Climate Change
LCI	Life cycle inventory analysis
LCIA	Life cycle impact assessment
LDPE	low-Density Polyethylene
LLDPE	Linear Low-Density Polyethylene
MJ	Megajoule
Nm ³	Normal-cubic metre (for gases)
NMVOG	Non-Methane-Volatile Organic Compounds
NOX	Nitrogen oxides
NR	Not Reported
FOEN	The Swiss Federal Office for the Environment
PAH	Polycyclic Aromatic Hydrocarbons
PE	PlasticsEurope
PE International	Consulting company which is known today under the name Sphera
S-PVC	Suspension Polyvinyl Chloride
UVEK 2021	Last published version of the UVEK database in a nomenclature based on ecoinvent v2
TOC	Total Organic compound
UBP	Environmental impact points
VOC	Volatile Organic Compounds

1 Introduction

The goal of this report is to document the life cycle inventory data for plastics as submitted to the commissioners.

[PlasticsEurope provides LCI data](#) for a variety of products. All datasets addressed for updates are documented as system processes. These data have been investigated by different consultancies, including IFEU and PE International, and are exclusively available in ILCD format.

ESU-services has implemented an LCI provided by [PlasticsEurope](#) in 2025. All data have been incorporated into the starting database BAFU:2024 provided by the commissioner.

The Federal Office for the Environment (FOEN) and ESU-services aim to establish a long-term cooperation for the regular update and extension of life cycle inventory data which feed the LCI models of FOEN Federal Office for the Environment (FOEN) and for which key LCI data can be given to interested parties. This includes e.g. data for the supply of natural gas and oil, and plastics. Key characteristics for this project are summarized in Tab. 1.1.

Tab. 1.1 Key characteristics of the project

Title	Life cycle inventories of plasticsLife cycle inventories of plastics
Commissioner	Federal Office for the Environment (FOEN) Federal Office for the Environment (FOEN), Monbijoustrasse 40, 3011 Berne Pierryves Padey, Project leader LCA, Economics and Innovation Division Tel +41 58 467 33 72, pierryves.padey@bafu.admin.ch , www.bafu.admin.ch
Products and variants investigated	Natural gas and crude oil extraction, transports, market mixes, plastics
Reference year	2023 – Latest data on methane emissions based on IEA as described in (Meili et al. 2025a)
Scope	Cradle to gate
Process stages	Production of basic plastics (without processing into products)
Key outcomes of the study	Provision of life cycle inventory data for import to the database of the commissioner (to be named later)
Standard to be applied	Frischknecht et al. 2007
Comparative study	No
Publication foreseen	Yes
Software for calculations	SimaPro 2025
Starting database and nomenclature	<ul style="list-style-type: none"> Data are based on UVEK DQRv2:2021 and have been provided in an internal database BAFU:2024 (starting database). The SimaPro starting database and the names list of processes and substances is provided by the commissioner at the project start and is used without changes. Data are provided for import to the BAFU:2024 database at project start. A matching list for process and substance names linking old nomenclature of UVEK 2021 and the BAFU:2024 nomenclature was provided by the commissioner
Data format	EcoSpold v1 XML as exported with Makro EcoSpoldAccess
Foreground data	Cumulative inventories of Plastics as provided by PlasticsEurope
Life cycle impact assessment	Internal quality check with Carbon footprint (IPCC 2021, 100a) and ecological scarcity method 2021 (FOEN 2021).
Validation	Commissioner

2 Goal and scope

This report describes updated life cycle inventory (LCI) data of plastic products produced in Europe in the RER zone, as well as the EU-27 and EU-28 states. The datasets listed in Tab. 2.1 are updated based on the reference year 2023 ([PlasticsEurope](#)).

The analysis of existing datasets has identified which LCI components show the highest influence when applying the life cycle impact assessment (LCIA) methods ‘Ecological Scarcity 2021, categories V1.04’, IPCC 2021 and CED (FOEN 2021; IPCC 2021; Huijbregts et al. 2010).

Most relevant for the update are fossil carbon dioxide and methane emissions (vented, fugitive and flaring) in the provision of crude oil and natural gas and direct energy uses during the manufacturing of the plastic products. Furthermore, the methane emissions are updated and described in chapter 3. The rest of substances and resources are updates based on LCI database provided by [PlasticsEurope](#) along with, generic data from previous studies to complete the LCIs (UVEK 2023).

Changes to the published data are made mainly according to the following data sources:

- Methane emissions are calibrated to ensure that the total inventoried emissions from crude oil and natural gas align with the global totals reported in actual studies (c.f. chapter 3.7).

Besides the data sources mentioned above, no further literature is specifically searched for. Plastics LCI database provided by [PlasticsEurope](#) is the basis of the update (Tab. 2.1).

Tab. 2.1 List of updated or new datasets for this project in UVEK 2021 and BAFU:2024 nomenclature, data downloaded on <https://plasticseurope.lca-data.com/>

UVEK 2021	BAFU:2024	PE original name	PE publication date
Ethylene, average, at plant/kg/RER	Ethylene, average, at plant {RER} U	Ethylene; production mix, at plant	2019
Polyethylene terephthalate, granulate, bottle grade, at plant/kg/RER	Polyethylene terephthalate, granulate, bottle grade, at plant {RER} U	PET, bottle grade, at plant; production mix, at plant	2019
Polyethylene, HDPE, granulate, at plant/kg/RER	Polyethylene, HDPE, granulate, at plant {RER} U	polyethylene, HDPE, granulate, at plant	2014
Polyethylene, LDPE, granulate, at plant/kg/RER	Polyethylene, LDPE, granulate, at plant {RER} U	polyethylene, LDPE, granulate, at plant	2014
Polyethylene, LLDPE, granulate, at plant/kg/RER	Polyethylene, LLDPE, granulate, at plant {RER} U	polyethylene, LLDPE, granulate, at plant	2014
Polypropylene, granulate, at plant/kg/RER	Polypropylene, granulate, at plant {RER} U	polypropylene, PP, granulate, at plant	2014
Polyvinylchloride, emulsion polymerised, at plant/kg/RER	Polyvinylchloride, emulsion polymerised, at plant {RER} U	polyvinyl chloride; from emulsion proces (E-PVC); at plant	2015
Polyvinylchloride, suspension polymerised, at plant/kg/RER	Polyvinylchloride, suspension polymerised, at plant {RER} U	polyvinyl chloride; from suspension process (S-PVC); at plant	2015
Pyrolysis gasoline, production mix, at plant/kg/RER	Pyrolysis gasoline, production mix, at plant {RER} U	Pyrolysis gasoline; production mix, at plant	2019
Purified terephthalic acid, at plant/kg/RER	Purified terephthalic acid, at plant {RER} U	Terephthalic acid, purified; production mix, at plant	2019
Vinyl chloride, at plant/kg/RER	Vinyl chloride, at plant {RER} U	vinyl chloride monomer; at plant	2015
Xylene, at plant/kg/RER	Xylene, at plant {RER} U	Xylenes, mixed; production mix, at plant	2019
Polystyrene, expandable, at plant/kg/RER	Polystyrene, expandable, at plant {RER} U	Expandable polystyrene (EPS), white and grey; suspension polymerisation, extrusion or mass pelletisation; production mix, at producer	2015
Ethylene glycol, at plant/kg/RER	Ethylene glycol, at plant {RER} U	Ethylene glycol; production mix, at plant	2019

3 Assumptions for the implementation

3.1 Introduction

The steps for implementing datasets (Tab. 2.1) are as follows:

- Implementation of downloaded data in Excel2EcoSpold template
- Replacement of substance names with list of substances available in the database of the commissioner
- Assumptions on waste disposal with link to background data available in BAFU:2024
- Implementation of emission factor for methane harmonized with oil and gas data investigated for the same project (Bussa et al. 2025; Meili et al. 2025a; Meili et al. 2025b). The factor is based on the recorded amount of crude oil and natural gas resource in the dataset.

Background data was used for plastic production, which was collected by IFEU through a questionnaire sent to [PlasticsEurope](#) members. For import into the database, the links to waste management background data were adjusted, and newer data for the methane emissions from crude oil and natural gas production was considered.

3.2 Special issues of plastics data

The datasets of [PlasticsEurope](#) addressed for the update are exclusively available in ILCD format. They are elaborated by different parties, including IFEU and PE International. All datasets addressed for the updates are nowadays only available as system processes and therefore are modelled accordingly in this study.

3.3 Waste disposal

For the import of EcoSpold data from [PlasticsEurope](#) into SimaPro, existing disposal processes in the EcoSpold files (provided in Excel format) are replaced by the corresponding processes from the BAFU:2024 database. If no specific disposal process is available in the BAFU:2024, it is substituted with a non-specific disposal process (e.g., "disposal, sodium sulphate" → "disposal, inert waste"). The processes in [PlasticsEurope](#) are specified for RER, whereas during import into the BAFU:2024, the corresponding processes only available for CH or DE are used.

Tab. 3.1 Assignment of waste processes from PlasticsEurope to the BAFU:2024 database (Wfd = waste for disposal; Wfr = waste for recovery)

Waste in PlasticsEurope	BAFU:2024 database
Ashes and slags (wfr)	Disposal, average incineration residue, 0% water, to residual material landfill {CH} U
Ashes from fluidized-bed incinerator (wfr)	Disposal, average incineration residue, 0% water, to residual material landfill {CH} U
Ash	Disposal, average incineration residue, 0% water, to residual material landfill {CH} U
Catalysts, used (wfr)	disposal, catalyst for EDC production, 0% water, to hazardous waste incineration {CH} U
Coarse ashes (wfr)	disposal, hard coal ash, 0% water, to residual material landfill {DE} U
Filter dust (wfr)	disposal, filter dust Al electrolysis, 0% water, to residual material landfill {CH} U
Gypsum from flue gas cleaning (wfr)	disposal, gypsum, 19.4% water, to inert material landfill {CH} U
Hazardous waste (wfr)	disposal, hazardous waste, 0% water, to underground deposit {DE} U
Hazardous waste for recovery (wfr)	disposal, hazardous waste, 25% water, to hazardous waste incineration {CH} U
Hazardous waste for further processing	disposal, hazardous waste, 25% water, to hazardous waste incineration {CH} U
Melting chamber granulate (wfr)	disposal, plastic plaster, 0% water, to sanitary landfill {CH} U
Non-hazardous waste (wfr)	disposal, municipal solid waste, 22.9% water, to municipal incineration {CH} U
Non-hazardous waste for recovery (wfr)	disposal, municipal solid waste, 22.9% water, to municipal incineration {CH} U
Scrap (iron) (wfr)	Iron scrap, from concrete demolition, at plant {CH} U
Sewage sludge (wfr)	disposal, raw sewage sludge, to municipal incineration {CH} U
Sodium sulphate (wfr)	disposal, inert waste, 5% water, to inert material landfill {CH} U
Waste oil (wfr)	disposal, used mineral oil, 10% water, to hazardous waste incineration {CH} U
Low-radioactive waste (wfd)	disposal, hazardous waste, 0% water, to underground deposit {DE} U
High-radioactive waste (wfd)	disposal, hazardous waste, 0% water, to underground deposit {DE} U
Medium-radioactive waste (wfd)	disposal, hazardous waste, 0% water, to underground deposit {DE} U
Medium and low radioactive liquid waste	disposal, hazardous waste, 0% water, to underground deposit {DE} U

Waste in PlasticsEurope	BAFU:2024 database
Waste, unspecified (wfd)	disposal, municipal solid waste, 22.9% water, to municipal incineration {CH} U
Waste, unspecified (wfr)	disposal, municipal solid waste, 22.9% water, to municipal incineration {CH} U
Waste for disposal (unspecified)	disposal, municipal solid waste, 22.9% water, to municipal incineration {CH} U
Waste to recovery (unspecified)	disposal, municipal solid waste, 22.9% water, to municipal incineration {CH} U
Waste salt from KCl-production (wfr)	Disposal, salt tailings potash mining, 0% water, to residual material landfill {CH} U
Waste of foil (inline recycling)	Disposal, municipal solid waste, 22.9% water, to municipal incineration {CH} U
Uranium	disposal, hazardous waste, 0% water, to underground deposit {DE} U
sodium hydroxide	disposal, hazardous waste, 0% water, to underground deposit {DE} U
Cerium	Disposal, sludge from FeCl ₃ production, 30% water, to underground deposit {DE} U
Benzal chloride	Disposal, emulsion paint, 0% water, to municipal incineration {CH} U
Methyl borate	Disposal, emulsion paint, 0% water, to municipal incineration {CH} U
BTEX (Benzene, Toluene, Ethylbenzene, and Xylene), unspecified ratio	Disposal, emulsion paint, 0% water, to municipal incineration {CH} U
tailings (deposited)	Disposal, salt tailings potash mining, 0% water, to residual material landfill {CH} U
spoil (deposited)	Disposal, spoil from lignite mining, in surface landfill {GLO} U
Overburden (deposited)	Disposal, salt tailings potash mining, 0% water, to residual material landfill {CH} U
Radioactive tailings	Disposal, hazardous waste, 0% water, to underground deposit {DE} U

3.4 Assignment of substances and resources

For some substances and resources, there is no exact match in the BAFU:2024 database. The assignments shown below have been made for this purpose. The compartment of the particular substance is not shown for the BAFU:2024 names below, since the specific compartment is already described in the left column.

Tab. 3.2 Assignment of substance names from PlasticsEurope to the BAFU:2024 database

Substances in PlasticsEurope	BAFU:2024 database
Octene	Octene (mixture of isomers)
Biological Oxygen Demand (Waterborne emissions)	BOD5, Biological Oxygen Demand
Chemical Oxygen Demand (Waterborne emissions)	COD, Chemical Oxygen Demand
1,1-dichloroethane (Waterborne emissions)	Ethane, 1,1-dichloro-
1,1-dichloroethane (Airborne emissions)	Ethane, 1,1-dichloro-
1,1-dichloroethane (emissions to soil)	Ethane, 1,1-dichloro-
Hydrocarbons, fully chlorinated, fluorinated (CFC) (Airborne Emissions)	Hydrocarbons, fully chlorinated, fluorinated (CFC)
Chloroethane (Airborne Emissions)	Ethane, chloro-
Monochloroethane (Airborne Emissions)	Ethane, chloro-
Monochloroethane (Waterborne emissions)	Ethane, chloro-
Chloroethane (Waterborne emissions)	Ethane, chloro-
Chloroethane (Emissions to soil)	Ethane, chloro-
VOX, volatile organic halogens (Waterborne emissions)	VOC, volatile organic compounds, unspecified origin
butylene glycol (Airborne Emissions)	1,4-Butanediol
hydrocarbons (unspecified) (Airborne Emissions)	Hydrocarbons, aliphatic, alkanes, unspecified
methane (fossil) (Airborne Emissions)	Methane, fossil
FC-14 (Airborne Emissions)	Methane, tetrafluoro-, R-14
2-methyl-2-butene (Airborne Emissions)	2-Butene, 2-methyl-
carbon monoxide (non-fossil) (Airborne Emissions)	Carbon monoxide, biogenic
particles (> PM10) (Airborne Emissions)	Particulates, > 10 um
carbon dioxide (biogenic) (Airborne Emissions)	carbon dioxide, biogenic
Pentachlorophenol (Airborne Emissions)	Phenol, pentachloro-
Arsenic, ion (Emissions to water)	Arsenic
Methane (Emissions to air)	Methane, fossil

Substances in PlasticsEurope	BAFU:2024 database
γ-butyrolactone (Airborne Emissions)	Butyrolactone
n-butanol (Airborne Emissions)	1-butanol
vinyl chloride (Airborne Emissions)	Ethene, chloro-
hydrogen-3 (Airborne Emissions)	Hydrogen-3, Tritium
Dichloromethane (Airborne Emissions)	Methane, dichloro-, HCC-30
HFC-116 (Airborne Emissions)	Ethane, hexafluoro-, HFC-116
Hexachlorobenzene (Airborne Emissions)	Benzene, hexachloro-
methane (biogenic) (Airborne Emissions)	Methane, biogenic
carbon monoxide (Airborne Emissions)	Carbon monoxide, fossil
Chlorobenzene (Airborne Emissions)	Benzene, chloro-
HFC-23 (Airborne Emissions)	Methane, trifluoro-, HFC-23
Pentachlorobenzene (Airborne Emissions)	Benzene, pentachloro-
carbon dioxide (fossil) (Airborne Emissions)	Carbon dioxide, fossil
tert-butyl methyl ether (Airborne Emissions)	t-Butyl methyl ether
Ethylenediamine (Airborne Emissions)	Ethylene diamine
HFC-134a (Airborne Emissions)	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a
Arsenic V (Airborne Emissions)	Arsenic
Methacrylate (Airborne Emissions)	Methyl acrylate
Radioactive isotopes (Airborne Emissions)	Radioactive species, other beta emitters
total organic carbon (Emissions to soil)	carbon
Calcium (waterborne Emissions)	calcium, ion
nitrogen, total (excluding N₂) (waterborne Emissions)	Nitrogen
adsorbable organic halogen compounds (waterborne Emissions)	AOX, Adsorbable Organic Halogen as Cl
total organic carbon (waterborne Emissions)	TOC, Total Organic Carbon
Chlorobenzene (waterborne Emissions)	Benzene, chloro-
1,2-dichlorobenzene (waterborne Emissions)	o-Dichlorobenzene
xylene (all isomers) (waterborne Emissions)	Xylene

Substances in PlasticsEurope	BAFU:2024 database
hydrogen-3 (waterborne Emissions)	Hydrogen-3, Tritium
ethyl benzene (waterborne Emissions)	Benzene, ethyl-
Sodium (waterborne Emissions)	Sodium, ion
Arsenic V (waterborne Emissions)	Arsenic
1,2-dichloroethane (waterborne Emissions)	Ethane, 1,2-dichloro-
tert-butyl methyl ether (waterborne Emissions)	t-Butyl methyl ether
waste heat (waterborne Emissions)	Heat, waste
polycyclic aromatic hydrocarbons (waterborne Emissions)	PAH, polycyclic aromatic hydrocarbons
vinyl chloride (waterborne Emissions)	Ethene, chloro-
Tin (waterborne Emissions)	Tin, ion
hydrocarbons (unspecified) (waterborne Emissions)	Hydrocarbons, unspecified
acid (as H+) (waterborne Emissions)	Acidity, unspecified
biological oxygen demand (waterborne Emissions)	BOD5, Biological Oxygen Demand
Ethylenediamine (waterborne Emissions)	Ethylene diamine
Vanadium (waterborne Emissions)	Vanadium, ion
chemical oxygen demand (waterborne Emissions)	COD, Chemical Oxygen Demand
Ammonium (waterborne Emissions)	Ammonium, ion
2,3,7,8-tetrachlorodibenzo-p-dioxin (Airborne Emissions)	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin
2-chlorophenol (Airborne Emissions)	Phenol, 2-chloro-
ethyl benzene (Airborne Emissions)	Benzene, ethyl-
R-40 (Airborne Emissions)	Methane, monochloro-, R-40

Substances in PlasticsEurope	BAFU:2024 database
non-methane volatile organic compounds (Airborne Emissions)	NMVOC, non-methane volatile organic compounds, unspecified origin
Plutonium (Airborne Emissions)	plutonium-alpha
Isobutanol (Airborne Emissions)	2-Methyl-1-propanol
Carbon dioxide (land use change) (Airborne Emissions)	Carbon dioxide, land transformation
Tetrachloroethene (Airborne Emissions)	Ethene, tetrachloro-
xylene (all isomers) (Airborne Emissions)	Xylene
n-propanol (Airborne Emissions)	1-propanol
particles (PM10) (Airborne Emissions)	Particulates, < 10 um
particles (PM2.5 - PM10) (Airborne Emissions)	Particulates, > 2.5 um, and < 10um
particles (PM2.5) (Airborne Emissions)	Particulates, < 2.5 um
Isopropanol (Airborne Emissions)	2-Propanol
3-methylbutan-1-ol (Airborne Emissions)	3-Methyl-1-butanol
methyl isobutyl ketone (Airborne Emissions)	4-Methyl-2-pentanone
Trifluoroacetic acid (Airborne Emissions)	Acetic acid, trifluoro-
Arsenic V (Airborne Emissions)	Arsenic
Hydrogen arsenide (Airborne Emissions)	Arsine
Benzo[a]pyrene (Airborne Emissions)	Benzo(a)pyrene
n-butane (Airborne Emissions)	Butane
Nitrous oxide (Airborne Emissions)	Dinitrogen monoxide
HCFC-140 (Airborne Emissions)	Ethane, 1,1,1-trichloro-, HCFC-140
1,1,1-trifluoroethane (Airborne Emissions)	Ethane, 1,1,1-trifluoro-, HFC-143a
1,1,2-trichlorotrifluoroethane (Airborne Emissions)	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113
HCFC-141b (Airborne Emissions)	Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b
HFC-152a (Airborne Emissions)	Ethane, 1,1-difluoro-, HFC-152a
1,2-dichloroethane (Airborne Emissions)	Ethane, 1,2-dichloro-
CFC-114 (Airborne Emissions)	Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114
HCFC-142b (Airborne Emissions)	Ethane, 1-chloro-1,1-difluoro-, HCFC-142b

Substances in PlasticsEurope	BAFU:2024 database
HCFC-123 (Airborne Emissions)	Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123
HCFC-124 (Airborne Emissions)	Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124
CFC-115 (Airborne Emissions)	Ethane, chloropentafluoro-, CFC-115
HFC-116 (Airborne Emissions)	Ethane, hexafluoro-, HFC-116
HFC-125 (Airborne Emissions)	Ethane, pentafluoro-, HFC-125
Trichloroethene (Airborne Emissions)	Ethene, trichloro-
Acetylene (Airborne Emissions)	Ethyne
HCFC-22 (Airborne Emissions)	Methane, chlorodifluoro-, HCFC-22
HCFC-31 (Airborne Emissions)	Methane, chloro-fluoro-, HCFC-31
CFC-13 (Airborne Emissions)	Methane, chlorotrifluoro-, CFC-13
Chloromethane (Airborne Emissions)	Methane, monochloro-, R-40
CFC-12 (Airborne Emissions)	Methane, dichlorodifluoro-, CFC-12
HCFC-21 (Airborne Emissions)	Methane, dichlorofluoro-, HCFC-21
HFC-32 (Airborne Emissions)	Methane, difluoro-, HFC-32
CFC-10 (Airborne Emissions)	Methane, tetrachloro-, CFC-10
CFC-11 (Airborne Emissions)	Methane, trichlorofluoro-, CFC-11
HFC-23 (Airborne Emissions)	Methane, trifluoro-, HFC-23
Plutonium (Airborne Emissions)	Plutonium-alpha
Radioactive isotopes (Airborne Emissions)	Radioactive species, other beta emitters

Substances in PlasticsEurope	BAFU:2024 database
Water vapour (Airborne Emissions)	Water
(2,4-dichlorophenoxy)acetic acid (Emissions to soil)	2,4-D
Ametryne (Emissions to soil)	Ametryn
Londax (Emissions to soil)	Bensulfuron methyl ester
carfentrazone-ethyl (Emissions to soil)	Carfentrazone ethyl ester
butylene glycol (waterborne Emissions)	1,4-Butanediol
Isobutanol (waterborne Emissions)	2-Methyl-1-propanol
Isopropanol (waterborne Emissions)	2-Propanol
2-methyl-2-butene (waterborne Emissions)	2-Butene, 2-methyl-
Arsenic V (waterborne Emissions)	Arsenic
Barium sulphate (waterborne Emissions)	Barite
N-butyl-acetate (waterborne Emissions)	Butyl acetate
Cadmium (ii) (waterborne Emissions)	Cadmium
Chromium (iii) (waterborne Emissions)	Chromium
HCFC-140 (waterborne Emissions)	Ethane, 1,1,1-trichloro-, HCFC-140
Hexachloroethane (waterborne Emissions)	Ethane, hexachloro-
Tetrachloroethene (Waterborne Emissions)	Ethene, tetrachloro-
2-ethoxyethanol (waterborne Emissions)	Ethylene glycol monoethyl ether
Hydrogen-3 (waterborne Emissions)	Hydrogen-3, Tritium
Iron (ii) (waterborne Emissions)	Iron
Lithium (waterborne Emissions)	Lithium, ion
HCFC-21 (Waterborne Emissions)	Methane, dichlorofluoro-, HCFC-21
CFC-10 (waterborne Emissions)	Methane, tetrachloro-, CFC-10
2-methylpentane (waterborne Emissions)	Methyl pentane
Nickel (ii) (waterborne Emissions)	Nickel (ii)
Dinitrogen (waterborne Emissions)	Nitrogen
Nitrogen, total (excluding N2) (waterborne Emissions)	Nitrogen

Substances in PlasticsEurope	BAFU:2024 database
Perchlorate, ion (waterborne Emissions)	Perchlorate
Butyl benzyl phthalate (waterborne Emissions)	Phthalate, butyl-benzyl-
Dibutyl phthalate (waterborne Emissions)	Phthalate, dibutyl-
Dimethyl phthalate (waterborne Emissions)	Phthalate, dimethyl-
Silver (i) (waterborne Emissions)	Silver, ion
Sodium, ion (waterborne Emissions)	Sodium
Technetium-99 (waterborne Emissions)	Technetium-99m
Tellurium-123 (waterborne Emissions)	Tellurium-123m
Zinc (ii) (waterborne Emissions)	Zinc
FC-318 (waterborne Emissions)	Butane, perfluorocyclo-, PFC-318
N-butanol (Airborne Emissions)	Butanol
N-butyl-acetate (Airborne Emissions)	Butyl acetate
waste heat (Airborne Emissions)	Heat, waste
HCFC-21 (Airborne Emissions)	Methane, dichlorofluoro-, HCFC-21
polycyclic aromatic hydrocarbons (Airborne Emissions)	PAH, polycyclic aromatic hydrocarbons
Water from cooling (Emissions to water)	Cooling water

Tab. 3.3 Assignment of resources names from PlasticsEurope to BAFU:2024 database

Resources in PlasticsEurope	BAFU:2024
Anhydrite, in ground	Anhydrite
carbon dioxide (biogenic)	Carbon dioxide, in air
primary energy from hydro power	Energy, potential (in hydropower reservoir), converted
fluorine	Fluorine, 4.5% in apatite, 3% in crude ore
gold	Gold, Au 1.1E-4%, Ag 4.2E-3%, in ore
lead	Lead, Pb 0.014%, Au 9.7E-4%, Ag 9.7E-4%, Zn 0.63%, Cu 0.38%, in
molybdenum	Molybdenum, 0.010% in sulfide, Mo 8.2E-3% and Cu 1.83% in crude
construction site	Occupation, construction site
dump site	Occupation, dump site
forest	Occupation, forest
forest, extensive	Occupation, forest, extensive
forest, intensive	Occupation, forest, intensive
industrial area	Occupation, industrial area
traffic area, rail/road embankment	Occupation, traffic area, rail/road embankment
traffic area, rail network	Occupation, traffic area, rail network
traffic area, road network	Occupation, traffic area, road network
urban, discontinuously built	Occupation, urban, discontinuously built
peat, in ground	Peat
phosphorus	Phosphorus, 18% in apatite, 4% in crude ore
Pyrolusite, in ground	Pyrolusite
rhodium	Rhodium, Rh 2.4E-5%, Pt 4.8E-4%, Pd 2.0E-4%, Ni 3.7E-2%, Cu 5.2E
silver	Silver, 0.007% in sulfide, Ag 0.004%, Pb, Zn, Cd, In
from arable, non-irrigated	Transformation, from arable, non-irrigated
from dump site	Transformation, from dump site
from forest, primary	Transformation, from forest
from forest, extensive	Transformation, from forest, extensive
from forest, intensive	Transformation, from forest, intensive
from industrial area	Transformation, from industrial area
from mineral extraction site	Transformation, from mineral extraction site
from traffic area, rail network	Transformation, from traffic area, rail network
from traffic area, road network	Transformation, from traffic area, road network
from urban, discontinuously built	Transformation, from urban, discontinuously built
to arable, non-irrigated	Transformation, to arable, non-irrigated
to dump site	Transformation, to dump site
to forest	Transformation, to forest
to forest, extensive	Transformation, to forest, extensive
to forest, intensive	Transformation, to forest, intensive
to industrial area	Transformation, to industrial area
to mineral extraction site	Transformation, to mineral extraction site
to traffic area, rail/road embankment	Transformation, to traffic area, rail/road embankment
to traffic area, rail network	Transformation, to traffic area, rail network
to traffic area, road network	Transformation, to traffic area, road network
to urban, discontinuously built	Transformation, to urban, discontinuously built
water bodies	Occupation, water bodies
antimony	Antimony, resource correction
hafnium	Hafnium, resource correction

Resources in PlasticsEurope	BAFU:2024
sodium sulfate	Sodium sulphate, resource correction
artificial areas	Occupation, artificial areas
forest, natural	Occupation, forest, natural
forest, used	Occupation, forest, used
grassland	Occupation, grassland
grassland/pasture/meadow	Occupation, grassland/pasture/meadow
lakes, artificial	Occupation, lakes, artificial
traffic area	Occupation, traffic area
unspecified, used	Occupation, unspecified, used
urban	Occupation, urban
urban, green areas	Occupation, urban, green areas
carbon dioxide	Transformation, from unspecified, used
Particulates, unspecified	Transformation, from annual crop, non-irrigated
copper	Copper, 0.52% in sulfide, Cu 0.27% and Mo 8.2E-3% in crude ore
raw pumice	Basalt
natural gas; 44.1 MJ/kg	Gas, natural/m ³
ruthenium	Platinum
Wood, unspecified, standing	Wood, unspecified, standing/m3
stone	Basalt
peat; 8.4 MJ/kg	Peat
primary energy from waves	Energy, from hydro power
to urban	Transformation, to urban
to traffic area	Transformation, to traffic area
from agriculture	Transformation, from agriculture
from artificial areas	Transformation, from artificial areas
from forest, natural	Transformation, from forest, natural
from forest, used	Transformation, from forest, used
from grassland	Transformation, from grassland
from grassland/pasture/meadow	Transformation, from grassland/pasture/meadow
from traffic area	Transformation, from traffic area
from urban	Transformation, from urban
from urban, green areas	Transformation, from urban, green areas
from urban/industrial fallow	Transformation, from urban/industrial fallow
to agriculture	Transformation, to agriculture
to forest, natural	Transformation, to forest, natural
to forest, used	Transformation, to forest, used
to grassland	Transformation, to grassland
to grassland/pasture/meadow	Transformation, to grassland/pasture/meadow
to unspecified, used	Transformation, to unspecified, used
to urban, green areas	Transformation, to urban, green areas
to urban/industrial fallow	Transformation, to urban/industrial fallow
unspecified	Occupation, unspecified
from construction site	Transformation, from construction site
from unspecified	Transformation, from unspecified
to artificial areas	Transformation, to artificial areas
to construction site	Transformation, to construction site
to grassland, not used	Transformation, to grassland, not used
to unspecified	Transformation, to unspecified
wood; 14.7 MJ/kg	Wood, unspecified, standing/kg
Osmium	Platinum
Sodium bromide, in ground	Sodium bromide
brown coal; 11.9 MJ/kg	Energy, from coal, brown

Resources in PlasticsEurope	BAFU:2024
hard coal; 26.3 MJ/kg	Energy, from coal
Water, cooling, lake	Water, cooling, unspecified natural origin
water, cooling, river	Water, cooling, unspecified natural origin
water, cooling, salt, ocean	Water, cooling, unspecified natural origin
water, process, unspecified natural origin	water, process, unspecified natural origin/m3
Carbon, in organic matter, in soil	Carbon, organic, in soil or biomass stock
Gas, mine, off-gas, process, coal mining	Gas, mine, off-gas, process, coal mining/m3
Gas, natural, in ground	Gas, natural/m3
TiO ₂ , 54% in ilmenite, 2.6% in crude ore, in ground	TiO ₂ , 54% in ilmenite, 2.6% in crude ore
TiO ₂ , 95% in rutile, 0.40% in crude ore, in ground	TiO ₂ , 95% in rutile, 0.40% in crude ore
Ulexite, in ground	Ulexite
Sodium chloride, 2.68% in seawater	sodium chloride
water, process, lake	Water, lake
Water, process, river	Water, river
Occupation, agriculture + forest	Occupation, agriculture
crude oil; 42.3 MJ/kg	oil, crude
dinitrogen	Nitrogen
Palladium	Palladium, Pd 2.0E-4%, Pt 4.8E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore
barium sulfate	Barite
Copper	Copper, 0.52% in sulfide, Cu 0.27% and Mo 8.2E-3% in crude ore
inert rock	basalt
Kaolin	Kaolinite
Brown coal	Energy, from coal, brown
Rhodium	Rhodium, Rh 2.4E-5%, Pt 4.8E-4%, Pd 2.0E-4%, Ni 3.7E-2%, Cu 5.2E-2% in ore
Bentonite	clay, bentonite
Hard coal	Energy, from coal
Pit Methane	Gas, mine, off-gas, process, coal mining/m3
Platinum	Platinum, Pt 2.5E-4%, Pd 7.3E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore
natural gas	Gas, natural/m3
primary energy from geothermics	Energy, geothermal, converted
crude oil	Oil, crude
Nickel	Nickel, Ni 2.3E+0%, Pt 2.5E-4%, Pd 7.3E-4%, Rh 2.0E-5%, Cu 3.2E+0% in ore
Uranium	Energy, from uranium
calcium carbonate	calcite
Peat	Energy, from peat
antimonite	stibnite
ground water	Water, well
Freshwater	Water, fresh
lake water	water, lake
sea water	Water, salt, ocean
river water	Water, river
mineral extraction site	Occupation, mineral extraction site
agriculture, mosaic	Occupation, agriculture, mosaic
From unspecified	Transformation, from unknown
from forest, primary	Transformation, from forest, natural
from agriculture, mosaic	Transformation, from agriculture, mosaic
to unspecified	Transformation, to unknown

Resources in PlasticsEurope	BAFU:2024
from urban, continuously built	Transformation, from urban, continuously built
urban, continuously built	Occupation, urban, continuously built
to urban, continuously built	Transformation, to urban, continuously built
to agriculture, mosaic	Transformation, to agriculture
Baryte	Barite
Carbon dioxide	Carbon dioxide, in air
Occupation, unknown	Occupation, industrial area
Occupation, unspecified	Occupation, industrial area

3.5 Water balance

All datasets have been reviewed and adjusted where necessary. All water inputs are assigned to the region “RER”.

Tab. 3.4 Assignment of water inputs

Water Input PlasticsEurope	BAFU:2024
Lake water	Water, lake, RER m ³
Water, process, lake	Water, lake, RER m ³
Water, process, river	Water, river, RER m ³
Water, process, well, in ground	Water, well, RER m ³
Ground water	Water, well, RER m ³
River water	Water, river, RER m ³
Sea water	Water, unspecified natural origin, RER m ³
Water, salt, sole	Water, unspecified natural origin, RER m ³
Water, unspecified natural origin	Water, unspecified natural origin, RER m ³
Water, cooling, lake	Water, cooling, unspecified natural origin, RER m ³
Water, cooling, river	Water, cooling, unspecified natural origin, RER m ³
Water, cooling, salt, ocean	Water, cooling, unspecified natural origin, RER m ³
Water, cooling, well, in ground	Water, cooling, unspecified natural origin, RER m ³

For the modelling of water output in Water, RER (Waterborne Emissions), the existing inputs are summed up, and the proportion of water that evaporates (Water RER airborne emissions) was subtracted.

Tab. 3.5 Assignment of water outputs

Water Output PlasticsEurope	BAFU:2024
Water vapour	Water, RER (airborne emissions)
Water (evapotranspiration)	Water, RER (airborne emissions)
Water from cooling	Water, RER (Waterborne Emissions)
Water	Water, RER (Waterborne Emissions)
-	Water, RER (Waterborne Emissions)

3.6 Infrastructure

For all datasets, the inventory regarding infrastructure contributions was checked and supplemented. For the implementation, the dataset "Chemical plant, organics {RER}U" is used. The quantity is the standard amount for production of chemicals of 4.0E-10 p.

3.7 Methane emissions

The cumulative data from [PlasticsEurope](#) accounted for emissions in the provision of crude oil and natural gas are based partly on outdated inventory data. This may lead a significant under-estimation of methane emissions.

To correct the methane emission factor, the system processes of [PlasticsEurope](#) are adjusted. The current data has been evaluated regarding methane emissions per kg or MJ of crude oil or natural gas in the European mix as investigated in the project (Bussa et al. 2025; Meili et al. 2025a; Meili et al. 2025b) (Tab. 3.6). The methane emission (methane, fossil) is calculated based on the amount of crude oil and natural gas reserves used and is entered into the inventory. Compensation is made via the higher heating value for the additionally used gas and oil inputs. A natural gas density of 0.6629 kg/m³ is used to convert values expressed in kg to volume-based units (Bussa et al. 2025).

$$\text{methane, fossil/kg} = \text{oil, crude in ground/kg} * 0.0117 \text{ kg/kg} + \text{gas, natural/m}^3 * 0.006 \text{ kg/m}^3$$

The accounted emissions have been checked to ensure they are not lower than the emissions reported by [PlasticsEurope](#).

Additional methane emissions from further processing in manufacturing plastics are not considered. However, it is assumed that these are significantly lower than the emissions calculated above.

Tab. 3.6 Calculation of fossil methane emissions per input of oil and natural gas resources in inventories of Plastics Europe

		crude oil, market mix, at long distance transport {RER} U	Natural gas, high pressure, at consumer {RER} U	Oil, crude	Gas, natural/m3	Upper heating value
		kg	MJ	kg In	m3 In	MJ
Oil, crude	kg	1.0189	0.00046	1		46
Gas, natural/m3	m3	0.0850	0.0318		1	39.9
Upper heating value	MJ	50.2618	1.28876			
GWP total	kg	0.626	0.018	0.614	0.558	
GWP, methane		0.382	0.006			
GWP, methane calculated		0.382	0.006			
Methane, fossil	kg	0.0127	0.00019	0.0117	0.00600	

3.8 Obvious errors corrected in PE data

Preliminary calculations of results showed possible errors in the data published by PE.

According to the latest [PlasticsEurope](#) data, methane emissions were first estimated for **Poly-styrene expandable** seven times higher (0.226 kg vs. 0.031 kg) than previously estimated in BAFU:2024. This discrepancy is largely due to the significant consumption of [natural gas](#)—

[28.5 kg](#)—required to produce just 1 kg of polystyrene. Since such a high input is unrealistic a correction has been made.

We checked the original data for the emissions recorded for CO₂ including the CO₂ embodied in the product. Emissions calculated according to the inputs of oil, gas and coal are about 20 times higher than emissions expected according to the recorded and embodied CO₂ emissions. Thus, a correction factor of 6% has been applied for these 3 fossil resources to achieve realistic results.

The preliminary results showed that total impacts of updated “**Purified terephthalic acid**” are significantly higher than in the previous dataset. Purified terephthalic acid exhibits higher land occupation for non-radioactive wastes, referred in the LCI as “Volume occupied, underground deposit” ($4.53 \times 10^{-5} \text{ m}^3$). The value provided in other 13 datasets from [PlasticsEurope](#) is significantly lower—by a factor of 1000 times. Therefore, a correction factor of 1000 is assumed for this elementary flow.

Some plastics (e.g. **HDPE**) data showed a too low cumulative energy demand in the preliminary calculations (lower than the actual energy content of the plastic itself). We identified that the use of crude oil is reported with the unit MJ. But, in a former version of the data a similar amount of crude oil was reported as kg. Thus, we assumed that the correct unit for this flow should be kg. Other forms of energy such as hydro and solar are also reported as kg (which does not make any sense). Here we assumed the correct unit to be MJ, but these flows are of minor importance.

PlasticsEurope has been informed about these issues and confirmed that there might be such issues not yet corrected on their website.

3.9 Known problems

The LCI data of PE seems to inventory pesticides in different compartments (air, water, soil). The ecological scarcity method only characterizes emissions to agricultural soil and thus might underestimate these impacts.

The ecological scarcity method as provided by FOEN only characterizes the pure form of ions emitted to water. The correct label would be e.g. “chromium, ion” as used in the original PE datasets. It is recommended to apply the latest Append File in SimaPro to correct such errors. If the append file is applied, some corrections are made, but the change of total eco-points is less than 0.1% and thus does not seem to be too relevant.

3.10 Uncertainties

Uncertainties are roughly estimated for system processes and set to 5 for all issues in the pedigree matrix. Furthermore, the basic uncertainty for the type of input or output is factored in.

4 Life Cycle Inventory Analysis (LCI)

The updated data has been imported into the BAFU:2024 database library.

The life cycle inventories for the updated processes are provided as system process in the EcoSpold v1 format. The electronic data is including full EcoSpold v1 documentation.

Tab. 4.1 shows one example for the meta information and Tab. 4.3 shows one example for the modelled life cycle inventory for plastic products in Europe.

For internal checking, data were exported in the EcoSpold v1 format (XML) and imported to SimaPro 10.2.

Tab. 4.1 Meta information for the investigated life cycle inventories, Ethylene, average.

ReferenceFunction	Name	Ethylene, average, at plant (RER) U
Geography	Location	RER
ReferenceFunction	InfrastructureProcess	0
ReferenceFunction	Unit	kg
	IncludedProcesses	All processes are considered including waste treatment of process waste
	GeneralComment	A methane emissions update has been incorporated into the LCI of datasets downloaded from the PlasticsEurope website.
	InfrastructureIncluded	1
	Category	chemicals
	SubCategory	organic
TimePeriod	StartDate	2008
	EndDate	2023
	DataValidForEntirePeriod	1
	OtherPeriodText	time to which data mainly refer: 2008 - 2010, with the methane emission updates in 2023
Geography	Text	EU27 including Norway
Technology	Text	<p>The world-wide demand for lower olefins, i.e. ethylene, propylene and butadienes is higher than for any other chemical as they are the primary feedstock for most plastics, polymers and man-made fibres. But lower olefins are only found in very low concentrations in crude oil due to their high reactivity. It is thus necessary to split up longer, saturated hydrocarbons into shorter, unsaturated compounds using the large-scale cracking process.</p> <p>The chemical reaction for the cracking process is a dehydrogenation and can be affected either catalytically or thermally. In the European Union the steam cracking process which thermally induces the reaction accounts for the lion's share of the ethylene, propylene and butadiene production.</p> <p>Due to the rising demand for ethylene and propylene as precursors for the polymer production not only naphtha, but also gas fractions are used as feedstock for steam cracking. In the European Union they play a minor role, whereas in the USA even most crackers use gas feedstock.</p> <p>In the steam cracking process suitable hydrocarbons are heated to temperatures of up to 800 °C or even higher in the presence of steam to crack the molecules into the desired products - lower olefins.</p> <p>Only a limited number of international technology contractors licenses the equipment used for crackers. The generic design of the machines is quite similar. Little modifications help to optimize the plant performance according to local conditions. Besides differences in the furnace, pressure and temperature of the fractionation columns and refrigeration systems may also vary or turbo expanders may be in use.</p> <p>Regardless of feedstock or contractor a cracker may be separated into three sections namely pyrolysis, primary fractionation/compression and product fractionation. In the pyrolysis section the hydrocarbon feedstock is preheated and then vaporised with superheated steam before passing into long and narrow tubes arranged in a cracking furnace. The hydrocarbon feedstock is cracked into smaller molecules by controlling residence time, temperature profile and partial pressure. This process is highly endothermic and therefore requires a high energy input. Therefore the tubes of the furnace are heated to 750 - 875 °C by oil or gas fire burners. To reduce the partial pressure of the hydrocarbon mixture and to minimise coke formation high-pressure steam is injected which gives the process the name steam cracking. To quickly quench the product gases to 550 - 650°C and to recover heat for internal use, transfer line exchangers (TLEs) may be used.</p> <p>The primary fractionation and compression section consists of the primary fractionator (naphtha and gas oil feed only), quench tower, gas compressor and gas cleanup facilities. The primary fractionator is used to condense out and fractionate fuel oil streams produced from naphtha and gas oil fed crackers. The gases are de-superheated in the quench tower by a circulating oil or water stream. The circulating oil or water stream is used as a medium level heat source for the rest of the plant. Product gases from the quench tower are condensed by four or five stages of gas compression. The gas is cooled after each stage and passed through a liquid knock-out drum. Finally, acid gases and carbon dioxide are removed from the cracked gas.</p> <p>The chilling train usually consists of four or five successive stages of chilling, incorporating ethylene and propylene refrigeration as well as an elaborate self-refrigeration system. This produces hydrogen which is used for downstream hydrogenation, hydrotreating of the heavier products or sold as a product. The exact process flow sequence varies according to the feedstock and the design arrangement, but various fractionation towers are used to separate the desired products. This may include a sequence of de-methaniser, followed by a de-ethaniser. Bottoms from the de-ethaniser are directed to the de-propaniser and the de-butaniser. The lighter the feedstock, the fewer fractions need to be separated and the separation system may be constructed simpler. After separation the ethylene still contains undesirable acetylene and ethane. Acetylene is removed either by selective catalytic hydrogenation or by extractive distillation. After separation from ethylene ethane is recycled back to the cracker. Similarly the C3 fraction contains methyl acetylene and propadiene after separation. Selective hydrogenation is used to convert this into propylene and propane prior to separation in a C3 splitter.</p> <p>In the European Union crackers are basically fed with Naphtha and condensates, also called natural gas liquids (NGL). Both sorts of feedstock are very similar mixtures of hydrocarbons. Liquid feedstocks have a high share as they are transported easily. Other important feedstock for crackers in the EU are gas oil, butane, propane, refinery gas and ethane. Ethane mainly comes from North Sea gas fields whereas other feedstock gases come from refineries.</p>
	ProductionVolume	20,280 Kt in 2010 (share of APPE members is at least 90% of European production)
	SamplingProcedure	literature values based on European company surveys & European statistics
	Extrapolations	no extrapolation

Tab. 4.2 Meta information for the investigated life cycle inventories, some other products.

ReferenceFunction	Name	Polyethylene, LDPE, granulate, at plant (RER) U	Polyethylene terephthalate, granulate, bottle grade, at plant (RER) U	Polyethylene, LLDPE, granulate, at plant (RER) U	Polypropylene, granulate, at plant (RER) U
Geography	Location	RER	RER	RER	RER
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	kg	kg	kg	kg
TimePeriod	IncludedProcesses	All processes are considered including waste treatment of process waste	The polymer process, upstream processes like pX, PTA, and MEG production, electricity, and steam production as well as transportation of feedstock and waste treatment.	The polymer process, upstream processes like ethylene production, electricity, and steam production as well as transportation of feedstock and waste treatment.	The polymer process, upstream processes like propylene production, electricity, and steam production as well as transportation of feedstock and waste treatment.
	GeneralComment	A methane emissions update has been incorporated into the LCI of datasets downloaded from the PlasticsEurope website.	A methane emissions update has been incorporated into the LCI of datasets downloaded from the PlasticsEurope website.	A methane emissions update has been incorporated into the LCI of datasets downloaded from the PlasticsEurope website.	A methane emissions update has been incorporated into the LCI of datasets downloaded from the PlasticsEurope website.
	InfrastructureIncluded	1	1	1	1
	Category	plastics	plastics	plastics	plastics
	SubCategory	thermoplasts	thermoplasts	thermoplasts	thermoplasts
	StartDate	2011	2015	2011	2011
	EndDate	2023	2023	2023	2023
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText	time to which data mainly refer: 2011 with the methane emission updates in 2023	time to which data mainly refer: 2015 with the methane emission updates in 2023	time to which data mainly refer: 2011 with the methane emission updates in 2023	time to which data mainly refer: 2011 with the methane emission updates in 2023
	Geography	Text	EU27 including Norway and Switzerland	EU28 including Norway and Switzerland	EU27 including Norway and Switzerland
Technology	Text	The polymer process, upstream processes like ethylene production, electricity, and steam production as well as transportation of feedstock and waste treatment.	The dataset represents the production mix of commercial PET production technologies in Europe	The polymer process, upstream processes like ethylene production, electricity, and steam production as well as transportation of feedstock and waste treatment.	The polymer process, upstream processes like propylene production, electricity, and steam production as well as transportation of feedstock and waste treatment.
	ProductionVolume	referring to covered LDPE production (72.3% of 6,392 kt in 2011)	total European nameplate capacity (3.4 x 10 ⁶ t/year)	referring to covered LLDPE production (86.4% of 3,700 kt in 2011)	referring to covered PP production (76.7% of 10,972 kt in 2011)
	SamplingProcedure	Questionnaires sent out to all production units in Europe operated by PlasticEurope member companies.	Questionnaires sent out to all production units in Europe operated by CPME member companies.	Questionnaires sent out to all production units in Europe operated by PlasticEurope member companies.	Questionnaires sent out to all production units in Europe operated by PlasticEurope member companies.
	Extrapolations	no extrapolation	no extrapolation	no extrapolation	no extrapolation

5 Life cycle impact assessment (LCIA)

No detailed impact assessment or impact related interpretation is commissioned for this project. This chapter presents an overview of the impact assessment results. The results of the impact assessment of the old plastic datasets in the BAFU:2024 starting database are compared with the results of the new plastic datasets from this study.

5.1 Global warming

Fig. 5.1 illustrates a comparison of the carbon footprint between the new implementation and the data existing in the database. Carbon dioxide and methane are the most relevant emissions for the carbon footprint in all cases.

The result of the comparison shows that ten out of fourteen updated products have higher global warming impact compared with BAFU:2024. For pyrolysis gasoline which has been newly added to the library, there is no basis to compare (Tab. 5.1 and Fig. 5.1).

Differences are not only due to the increased emission of methane, but also due to other changes in the production chain leading to different CO₂ Emissions.

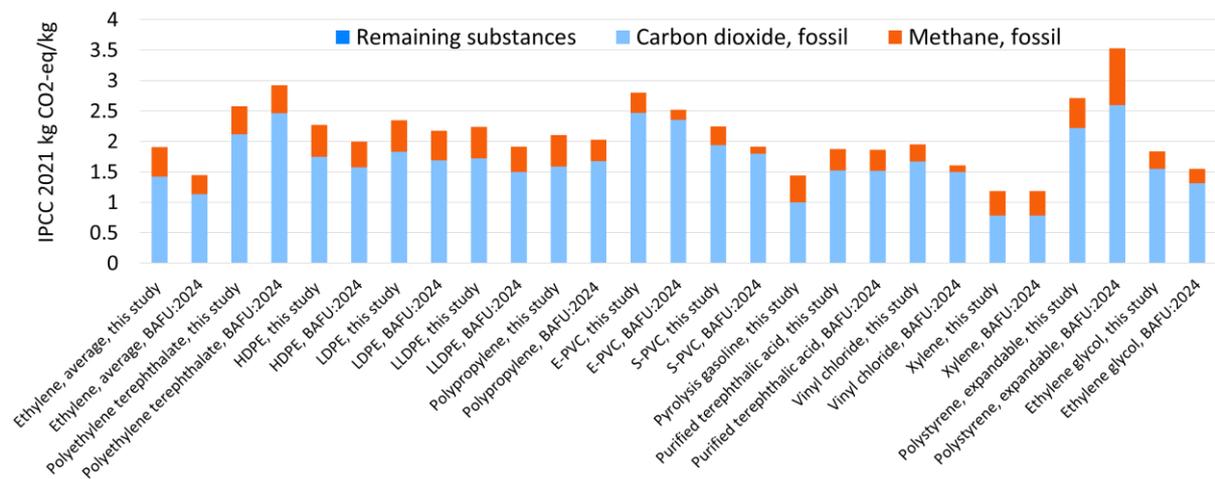


Fig. 5.1 Comparison of carbon footprint of existing LCI and newly implemented LCI

Tab. 5.1 Comparative results of GWP, IPCC 2021, 1 kg of plastic products as reference unit

Products	Unit	Carbon dioxide	Methane	Total	Difference %
Ethylene, average, this study	kg CO2 eq	1.418	0.486	1.4	132.01%
Ethylene, average, BAFU:2024	kg CO2 eq	1.131	0.315	2.6	
Polyethylene terephthalate, this study	kg CO2 eq	2.115	0.461	2.9	88.25%
Polyethylene terephthalate, BAFU:2024	kg CO2 eq	2.457	0.461	2.3	
HDPE, this study	kg CO2 eq	1.747	0.522	2.0	114.23%
HDPE, BAFU:2024	kg CO2 eq	1.574	0.421	2.4	
LDPE, this study	kg CO2 eq	1.819	0.522	2.2	108.50%
LDPE, BAFU:2024	kg CO2 eq	1.690	0.483	2.2	
LLDPE, this study	kg CO2 eq	1.720	0.516	1.9	117.19%
LLDPE, BAFU:2024	kg CO2 eq	1.498	0.418	2.1	
Polypropylene, this study	kg CO2 eq	1.588	0.516	2.0	104.15%
Polypropylene, BAFU:2024	kg CO2 eq	1.677	0.352	2.8	
E-PVC, this study	kg CO2 eq	2.467	0.332	2.5	111.33%
E-PVC, BAFU:2024	kg CO2 eq	2.352	0.163	2.3	
S-PVC, this study	kg CO2 eq	1.935	0.304	1.9	117.15%
S-PVC, BAFU:2024	kg CO2 eq	1.795	0.117	1.4	
Pyrolysis gasoline, this study	kg CO2 eq	1.000	0.440	1.9	NA
Purified terephthalic acid, this study	kg CO2 eq	1.520	0.353	1.9	100.90%
Purified terephthalic acid, BAFU:2024	kg CO2 eq	1.515	0.345	2.0	
Vinyl chloride, this study	kg CO2 eq	1.664	0.283	1.6	121.44%
Vinyl chloride, BAFU:2024	kg CO2 eq	1.499	0.104	1.2	
Xylene, this study	kg CO2 eq	0.780	0.407	1.2	100.00%
Xylene, BAFU:2024	kg CO2 eq	0.780	0.407	2.7	
Polystyrene, expandable, this study	kg CO2 eq	2.219	0.491	3.5	77.18%
Polystyrene, expandable, BAFU:2024	kg CO2 eq	2.591	0.932	1.8	
Ethylene glycol, this study	kg CO2 eq	1.549	0.287	1.6	118.66%
Ethylene glycol, BAFU:2024	kg CO2 eq	1.310	0.236	0.0	

5.2 Cumulative energy demand

Fig. 5.2 shows the cumulative energy demand of plastics by examining their reliance on different energy sources.

The results indicate that non-renewable fossil fuels account for the largest share of total energy consumption across all products. Comparative analysis reveals that seven out of the fourteen updated products require (slightly) more energy than the corresponding existing entries in the database, primarily due to increased use of oil and natural gas (Tab. 5.2).

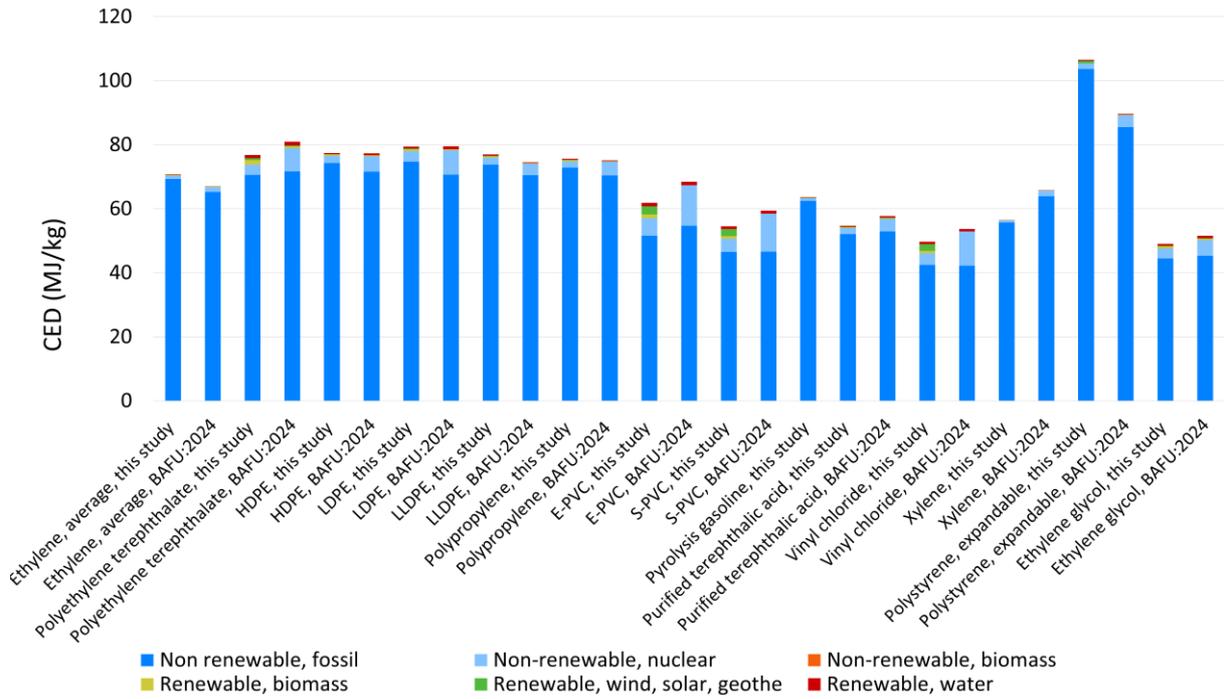


Fig. 5.3 Results for cumulative energy demand of existing LCI and newly implemented LCI

Tab. 5.3 Comparative results of cumulative energy demand, CED, 1 kg of plastic products as reference unit

Products	Unit	Total	Difference %
Ethylene, average, this study	MJ	70.74	106.17%
Ethylene, average, BAFU:2024	MJ	66.98	
Polyethylene terephthalate, this study	MJ	76.75	98.43%
Polyethylene terephthalate, BAFU:2024	MJ	80.91	
HDPE, this study	MJ	77.39	103.81%
HDPE, BAFU:2024	MJ	77.30	
LDPE, this study	MJ	79.42	105.68%
LDPE, BAFU:2024	MJ	79.53	
LLDPE, this study	MJ	76.96	104.68%
LLDPE, BAFU:2024	MJ	74.52	
Polypropylene, this study	MJ	75.63	103.38%
Polypropylene, BAFU:2024	MJ	75.12	
E-PVC, this study	MJ	61.87	94.21%
E-PVC, BAFU:2024	MJ	68.41	
S-PVC, this study	MJ	54.50	99.77%
S-PVC, BAFU:2024	MJ	59.42	
Pyrolysis gasoline, this study	MJ	63.58	NA
Purified terephthalic acid, this study	MJ	54.66	98.42%
Purified terephthalic acid, BAFU:2024	MJ	57.70	
Vinyl chloride, this study	MJ	49.72	100.70%
Vinyl chloride, BAFU:2024	MJ	53.68	
Xylene, this study	MJ	56.47	87.25%
Xylene, BAFU:2024	MJ	65.82	
Polystyrene, expandable, this study	MJ	106.51	121.23%
Polystyrene, expandable, BAFU:2024	MJ	89.62	
Ethylene glycol, this study	MJ	49.00	98.05%
Ethylene glycol, BAFU:2024	MJ	51.51	

5.3 Ecological scarcity method 2021

The ecological scarcity method assesses environmental impact by measuring emissions, resource use, and waste through Swiss eco-factors, quantified in eco-points (UBP). These eco-factors are determined based on current emissions relative to legislative targets. Ecological scarcity covers twenty one indicators evaluating key environmental factors, including biodiversity loss, climate change gases, pollutants, and radioactive waste (FOEN 2021).

The results show that total impacts of nine out of fourteen updated products are higher compared with BAFU:2024. Apart from climate change impact, in this study, water pollutants and persistent organic pollutants (POP) into water indicators show higher impacts for updated products (Fig. 5.4 and Tab. 5.4).

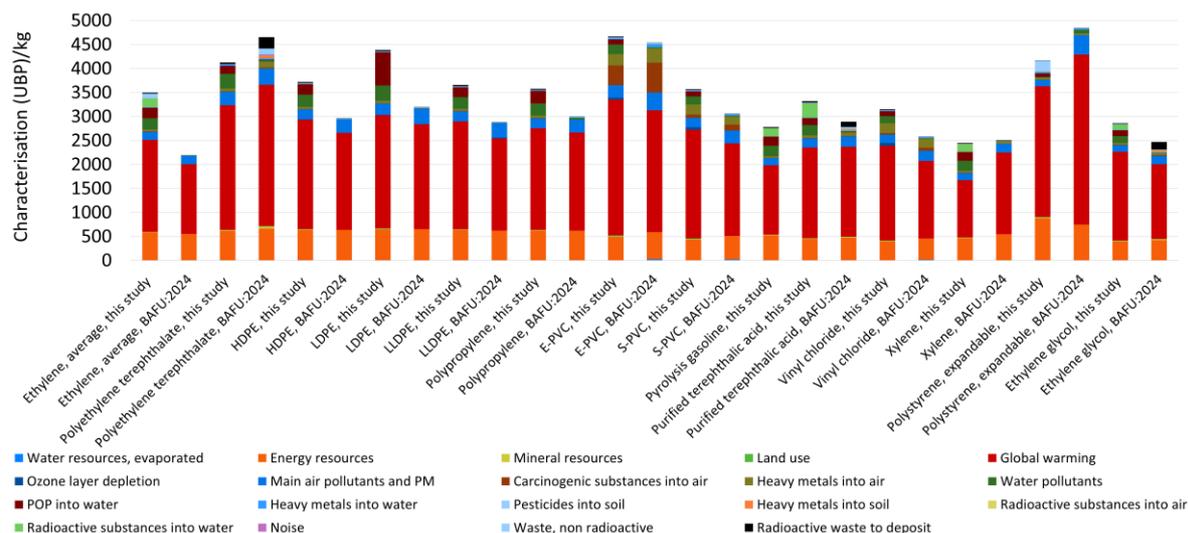


Fig. 5.4 Results for ecological scarcity of existing LCI and newly implemented LCI

Tab. 5.4 Comparative results of ecological scarcity indicators, 2021, single score, 1 kg of plastic products as reference unit

Products	Unit	Total	Difference %
Ethylene, average, this study	UBP	3'500	159.57%
Ethylene, average, BAFU:2024	UBP	2'194	
Polyethylene terephthalate, this study	UBP	4'131	88.73%
Polyethylene terephthalate, BAFU:2024	UBP	4'656	
HDPE, this study	UBP	3'722	125.56%
HDPE, BAFU:2024	UBP	2'965	
LDPE, this study	UBP	4'387	137.29%
LDPE, BAFU:2024	UBP	3'196	
LLDPE, this study	UBP	3'657	126.98%
LLDPE, BAFU:2024	UBP	2'880	
Polypropylene, this study	UBP	3'581	119.65%
Polypropylene, BAFU:2024	UBP	2'993	
E-PVC, this study	UBP	4'674	103.01%
E-PVC, BAFU:2024	UBP	4'538	
S-PVC, this study	UBP	3'574	116.82%
S-PVC, BAFU:2024	UBP	3'060	
Pyrolysis gasoline, this study	UBP	2'785	NA
Purified terephthalic acid, this study	UBP	3'322	114.87%
Purified terephthalic acid, BAFU:2024	UBP	2'892	
Vinyl chloride, this study	UBP	3'154	122.22%
Vinyl chloride, BAFU:2024	UBP	2'581	
Xylene, this study	UBP	2'453	97.73%
Xylene, BAFU:2024	UBP	2'510	
Polystyrene, expandable, this study	UBP	4'173	86.12%
Polystyrene, expandable, BAFU:2024	UBP	4'846	
Ethylene glycol, this study	UBP	2'861	115.76%
Ethylene glycol, BAFU:2024	UBP	2'471	

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