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BASE IMPACTS® DATA DOCUMENTATION

CATEGORY: PLASTICS, RESINS, FIBERS AND FILLERS

3 levels of documentation are available for the datasets in Base Impacts®:

- A **general documentation** explaining general information on the datasets and data general requirements
- A **sectorial documentation**: one document per sector describing the available datasets and their characteristics (technological representativeness, geographical representativeness), and providing the information on the datasets in a common layout. Information comes from the consultation specifications, the dataset commissioner technical proposal and the metadata
- The **datasets metadata** can be viewed directly in the datasets sheets. They include more detailed information (flow diagrams, Etc.)

This document is the category documentation for plastic.

CONTENTS

LIST OF ABBREVIATIONS	3
A. PRESENTATION OF THE DATASETS	4
1. List of available datasets	4
2. Structure of available datasets	8
B. SCOPE OF THE DATASETS	10
1. Reference flow, functional unit	10
2. System boundaries.....	10
2.1. General foreground system boundaries.....	10
2.2. Dataset-specific foreground system boundaries	10
C. DATA SOURCES AND QUALITY	39
2.3. Background system boundaries.....	39
1. Data quality requirements.....	40
2. Types and sources of data	40
3. Data quality	40
3.1. Technological representativeness	40
3.2. Time-related coverage	40
3.3. Geographical coverage.....	40
3.4. Precision.....	40
3.5. Completeness.....	40
3.6. Consistency	40
4. Multi-functionality and allocation procedure.....	41
4.1. Foreground system allocation procedure.....	41
4.2. Background system allocation procedure	41
D. CRITICAL REVIEW	41
E. REPORTS FOR MORE INFORMATION.....	41
F. ADMINISTRATIVE INFORMATION.....	42
1. Commissioner.....	42
2. Dataset modeler	42
APPENDIX: DATA NEED AND DATA SELECTION	43

LIST OF ABBREVIATIONS

ABS: Acrylonitrile-butadiene-styrene granulate

EPDM: Ethylene Propylene Diene Elastomer

EPS: expanded polystyrene

EVA: Ethylene vinyl acetate

IIR: Isobutylene Isoprene Rubber

NBR: Nitrile-Butadiene-Rubber

NR: Natural Rubber

PA: Nylon

PB: Polybutadiene

PC: Polycarbonate

PE: Polyethylene

PEHD: Polyethylene high density

PELD: Polyethylene low density

PELLD: Polyethylene low linear density

PEX: Crosslinked polyethylene

PET: Polyethylene terephthalate

PMMA: Polymethylmethacrylate-ball

POM: Polyoxymethylene

PS: Polystyrene

PVC: Polyvinylchloride

B-PVC: Polyvinylchloride resin (bulk)

E-PVC: Polyvinylchloride emulsion

S-PVC: Polyvinylchloride suspension

PTFE: Polytetrafluoroethylene

PU: Polyurethane

SAN: Styreneacrylonitrile

SBR: Styrene-Butadiene Rubber

SBS: Styrene butadiene copolymer

UP: Polyester Resin unsaturated

A. PRESENTATION OF THE DATASETS

1. List of available datasets

The following datasets are available:

Technological representativity		Geographical representativity	Dataset type	Scope	
THERMOPLASTICS – material					
ABS		Europe	LCI result ¹	Granulate production	
PA	Nylon 6 granulate (PA 6)	Europe	LCI result ¹	Granulate production	
	Nylon 6.6 granulate (PA 6.6)	Europe	LCI result ¹	Granulate production	
PC granulate		Europe	LCI result	Granulate production	
PE	PEHD	Polyethylene high density granulate (PE-HD)	Europe	LCI result ¹	Granulate production
		HDPE pipe, extruded	Europe	LCI result	Granulate production and processing
		HDPE, processed by injection moulding	Europe	LCI result	Granulate production and processing
	PELD granulate		Europe	LCI result ¹	Granulate production
	PELLD granulate		Europe	LCI result ¹	Granulate production
	PEX pipe, extruded		Europe	LCI result	Granulate production and processing
	PET	PET granulate, amorph		Europe	LCI result ¹
PET, processed by injection stretch blow moulding		Europe	LCI result	Granulate production and processing	
PMMA		Europe	LCI result ¹		
POM granulate		Europe	LCI result ¹	Granulate production	

¹ Error on this field in the online metadata (partly terminated system instead of LCI result)

Technological representativity		Geographical representativity	Dataset type	Scope
PP	PPgranulate	Europe	LCI result ¹	Granulate production
	PP pipe, extruded	Europe	LCI result	Granulate production and processing
	PP, processed by injection moulding	Europe	LCI result	Granulate production and processing
	PP/EPDM Granulate Mix	Europe	LCI result ¹	Granulate production
PS	PS granulate	Europe	LCI result ¹	Granulate production
	EPS granulate	Europe	LCI result ¹	Granulate production
	EPS-Foam	Europe	LCI result	Granulate production and processing
PVC	B-PVC granulate	Europe	LCI result ¹	Granulate production
	E-PVC granulate	Europe	LCI result ¹	Granulate production
	S-PVC granulate	Europe	LCI result ¹	Granulate production
	PVC film, calendered	Europe	LCI result	Granulate production and processing
	PVC pipe, extruded	Europe	LCI result	Granulate production and processing
	PVC, processed by injection moulding	Europe	LCI result	Granulate production and processing
SAN		Europe	LCI result	
THERMOPLASTICS - forming				
Thermoforming	Infrared Thermoforming , LD-PE Part, Ceramic at 950°F/510°C	Europe	Partly terminated system	Processing
	Infrared Thermoforming , PMMA Part, Quartz at 1400°F/760°C	Europe	Partly terminated system	Processing
Plastic extrusion (unspecific)		EU-27 Member States	Partly terminated system	Processing
Plastic injection molding part		Europe	Partly terminated system	Processing

Technological representativity		Geographical representativity	Dataset type	Scope
THERMOSETS				
Epoxy resin		Europe	LCI result	
EVA (72% ethylene, 28% vinyl acetate)		Europe	LCI result	
PTFE granulate Mix		Europe	LCI result ¹	Granulate production
PU	PU flexible foam	Europe	LCI result	Granulate production and processing
	PU rigid foam	Europe	LCI result	Granulate production and processing
UP resin		Europe	LCI result	
ELASTOMERS				
Butadiene		Europe	LCI result	
Butyl rubber – IRR by emulsion polymerization		Europe	LCI result	
NR		Europe	LCI result	
NBR		Europe	LCI result	
PB	PB granulate	Europe	LCI result ¹	Granulate production
	PB rubber	Europe	LCI result	Granulate production and processing
Styrene	SBR Mix	Europe	LCI result	Granulate production and processing
	SBS	Europe	LCI result	Granulate production and processing
RESINS AND FIBERS				
glass fiber	Glass fiber, short / low strength	Europe	LCI result	Fiber production
	Glass fiber, long / high strength	Europe	LCI result	Fiber production
carbon fiber	Carbon fiber, short / low strength	Europe	LCI result	Fiber production
	Carbon fiber, long / high strength	Europe	LCI result	Fiber production
melamin-formaldehyde resin		Europe	LCI result	Resin production
phenolic resin (45% concentration)		Europe	LCI result	Resin production
Urea formaldehyde resin in- situ foam		Europe	LCI result	Resin production
RESINS AND FIBERS- PROCESSES				
Pultrusion		World	Unit process, single operation	Processing

Thermocompression	World	Unit process, single operation	Processing
FILLERS			
Carbon black (furnace black; general purpose)	Europe	LCI result	Filler production
Zinc oxide	Europe	LCI result	Filler production
Zinc oxide (from refined zinc)	Europe	LCI result	Filler production
Sulphur (elemental) at refinery	Europe	LCI result	Filler production

Table 1 : Available datasets

2. Structure of available datasets

Datasets must be distinguished between “partly terminated systems” and “LCI results”.

The following diagram is used to present the structure of the datasets:

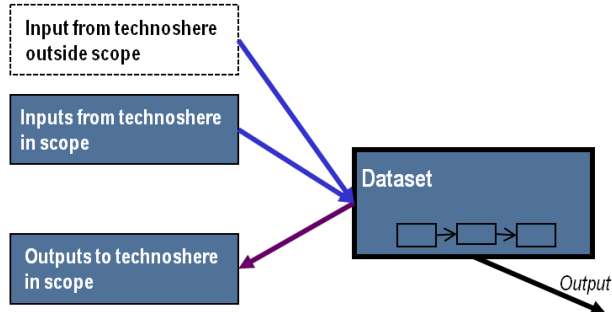


Figure 1 : Structure of the datasets

- The “LCI result” datasets represent a whole production process.

They represent inventories where the material and the process have already been aggregated. For example, “PP pipe, extruded” results from the aggregation of PP granulate dataset and extrusion process dataset.

The LCI results datasets include the following elements:

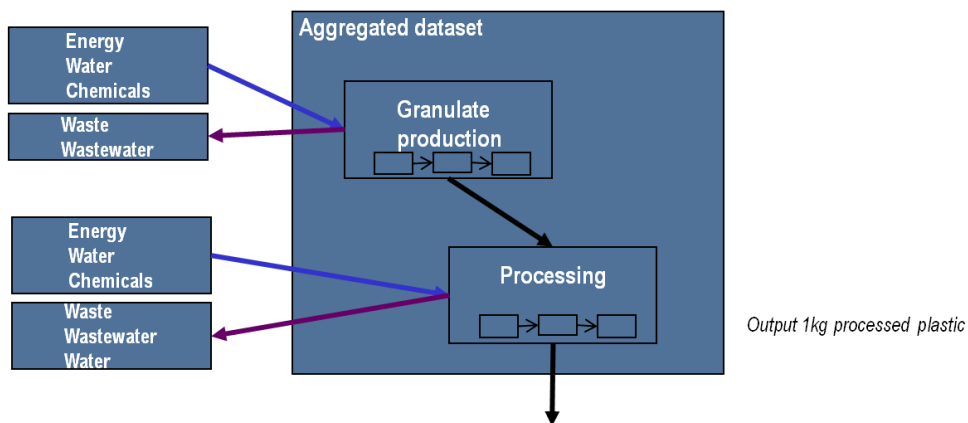


Figure 2 : Structure of the datasets – “LCI results”

- The “partly terminated systems” datasets cannot be used alone to model a given product, but must be complemented with processing datasets.

When aggregating a partly terminated system with a process data (e.g. “Nylon 6 granulate” with “plastic injection moulding”), the waste rate of the process must be taken into account. The average waste rates, given in the metadata, are the following:

Process		Waste rate
Infrared Thermoforming	LD-PE Part, Ceramic at 950°F/510°C	0%
	PMMA Part, Quartz at 1400°F/760°C	0%
Plastic extrusion (unspecific)		5%
Plastic injection moulding		2%
Pultrusion		1%
Thermocompression		1%

Table 2: Waste rates of the process dataset available in the database

The “partly terminated systems” datasets include the following elements:

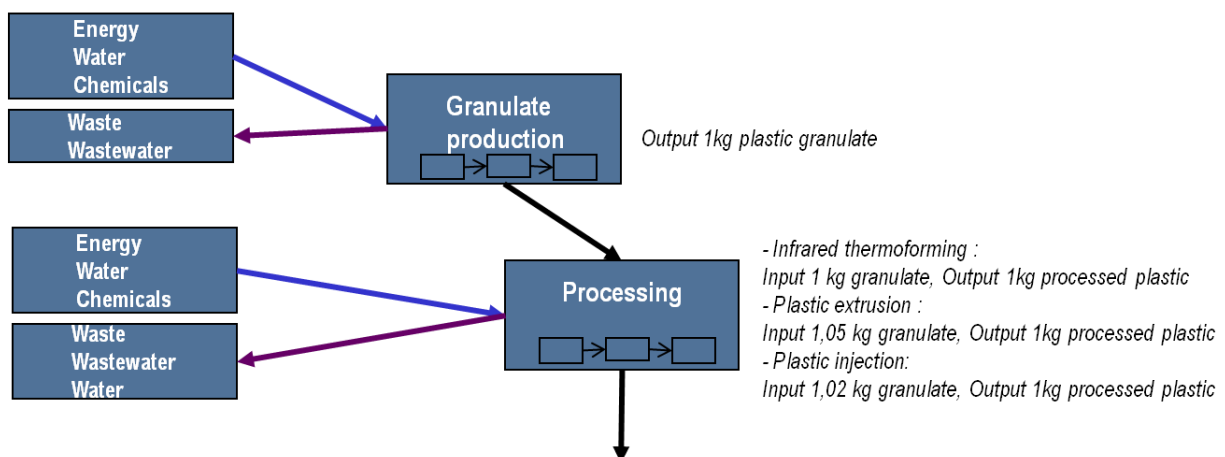


Figure 3 : Structure of the datasets – “partly terminated systems”

For instance, if the modeler needs to model 1 kg of injected polyamide, the following elements must be modeled by taking into account the yield of the processes:

- 1 kg plastic injection
- 1 x 1,02 kg polyamide

Note: The aggregated datasets include forming processes which are specific to the polymer type (amount of energy, type of plastics waste, Etc.). This is more relevant than the unspecific forming dataset. Besides, they include the default waste rate.

Therefore, aggregated dataset should rather be used when they are provided.

B. SCOPE OF THE DATASETS

1. Reference flow, functional unit

The processes are provided for 1 kg of output.

2. System boundaries

2.1. General foreground system boundaries

No general rules are defined.

2.2. Dataset-specific foreground system boundaries

2.2.1. Thermoplastics materials

2.2.1.1. Acrylonitrile-butadiene-styrene granulate (ABS)

Technology description and included processes:

ABS takes its name from the initial letters of the three immediate precursors (acrylonitrile, butadiene, styrene) and is a two phase polymer system consisting of a glassy matrix of styrene-acrylonitrile copolymer and the synthetic rubber, styrene-butadiene copolymer. ABS is technically produced by co- or graft co-polymerization of the three base monomers in emulsion or mass polymerization. By varying the share of monomer input the technical properties of ABS are influenced.

Data cut-off and completeness principles:

All relevant mass and energy flows are included in the inventory; no specific cut-off rule is applied.

Data sources:

- Boustead Model
- Ecoprofile ABS

2.2.1.2. Nylon (PA) granulate

To fulfill the requirement of the Base Impacts®, two types of nylon granulate are provided: nylon 6 and nylon 6-6.

Technology description and included processes:

- **Nylon 6 granulate (PA 6):** There are a number of different routes to the production of nylon 6. The starting chemical is benzene, which is used to produce cyclohexanone. This conversion can be achieved by two distinct routes. One route hydrogenates the benzene to produce cyclohexane, which is then oxygenated to give cyclohexanone. The alternative route is to react the benzene with propylene. This gives cumene that can then be oxygenated to phenol giving acetone as by-product. The phenol can then be hydrogenated to cyclohexanone.

The cyclohexanone is then converted into the oxime by reacting with hydroxylamine (NH₂OH). Finally the oxime is converted to caprolactam, the immediate precursor for nylon 6, by an acid catalysed reaction called the Beckmann rearrangement. The most common route employs sulphuric acid but an alternative uses phosphoric acid.

- **Nylon 6.6 granulate (PA 6.6):** The essential precursors for nylon 66 are hexamethylene diamine, H₂N-(CH₂)₆-NH₂, and adipic acid, HOOC-(CH₂)₄-COOH. When they are reacted they produce hexamethylene diammonium adipate, commonly referred to as nylon salt, H₃N(CH₂)₆NH₃OOC(CH₂)₄COO.

For fibre applications, it is important to ensure that the precursors are reacted in equimolar proportions and that the product is highly purified. The formation, extraction and purification of the salt ensure that these conditions are met.

Adipic acid is made by the oxidation of cyclohexane to a mixture of cyclohexanol and cyclohexanone (called KA oil). This mixture is further oxidised with nitric acid to adipic acid.

Hexamethylene diamine is made by the reduction of adiponitrile, which is made either by the electronic coupling of acrylonitrile or by the hydrocyanation of butadiene.

Adipic acid and hexamethylene diamine are combined in water to make a salt solution. This solution is then passed through a batch or continuous reactor in which the water is removed at high temperature and the nylon polymerizes. The polymer is expelled from the reactor and granulated. Higher molecular weights are achieved by solid phase polymerization.

Modified nylons are made by extrusion compounding of the nylon with the modifiers or reinforcements. In some cases, it is possible to compound directly at the reactor without granulating the nylon.

Data cut-off and completeness principles:

All relevant mass and energy flows are included in the inventory; no specific cut-off rule is applied.

Data sources:

- Boustead Model
- Ecoprofile Nylon6
- Plastics Europe
- EC, DG ENV
- EPLCA project team
- ADEME

2.2.1.3. Polycarbonate granulate (PC)

Technology description and included processes:

Both Interfacial Polycondensation and Melt Transesterification process are currently being used in the industrial production of Polycarbonate.

In the interfacial process, Bisphenol A is reacted with phosgene at 20-40°C in a two-phase mixture consisting of an aqueous, alkaline phase (e.g. use of NaOH) and an immiscible organic phase. These main starting compounds Bisphenol A and phosgene are produced in the following way:

Bisphenol A is mainly produced by the condensation of acetone and phenol. Both intermediates can be produced from the oxidation of cumene (Hock process), coming from the reaction between benzene and propylene. Propylene is produced from the cracking

naphtha and benzene is produced either from reformation of gasoline, pyrolysis of gasoline or from toluene dealkylation.

Phosgene is produced by passing chlorine from the electrolysis of sodium chloride and an excess of carbon monoxide over activated carbon at 400°C. Carbon monoxide is manufactured from synthesis gas, which is best produced from water (steam) and methane (natural gas). The latter can be replaced with other hydrocarbons and mixtures thereof, e.g. naphtha or fuel oils.

In the melt transesterification process, diphenyl carbonate (DPC) is transesterified in the melt with bisphenol A to form polycarbonate. DPC for this reaction can be manufactured by phosgenation of phenol. Another possibility is the reaction of carbon monoxide with alcohols in the presence of catalysts giving dialkyl carbonates that can, in turn, be reacted with phenol to form diphenyl carbonate.

Data cut-off and completeness principles:

In the foreground processes all relevant flows were considered, trying to avoid any cut-off of material and energy flows. In single cases additives used in the PC unit process (<0.2% m/m of PC output) were neglected. This was done in agreement with the producer due to the complex mixture of chemicals used and lack of information on the amount of each substance used. Nevertheless it was assured that no hazardous substances or metals were present in this neglected part. According to the GaBi Databases 2006, used in the background processes, at least 95% of mass and energy of the input and output flows were covered and 98% of their environmental relevance (according to expert judgment) was considered, hence an influence of cut-offs less than 1% on the total is expected.

2.2.1.4. Polyethylene (PE)

To fulfill the requirement of the Base Impacts®, three types of polyethylene granulate are provided:

- high density PE (PE-HD),
- low density PE (PE-LD) and
- low linear density PE (PE-LLD).

In addition, datasets are provided for:

- HDPE pipe, extruded
- HDPE, processed by injection moulding,
- PEX pipe, extruded.

Technology description and included processes:

- **Polyethylene high density granulate (PE-HD)** has the same repeat unit as LDPE and is usually regarded as polyethylene with a density greater than 940 kg m⁻³. It is produced in low pressure reactors and so is often referred to as low pressure polyethylene. It differs from LDPE in that it contains fewer side branches at 5 to 10 per 1000 carbon atoms on the backbone. Most of the side branches are short with long side branches being rare. Molecular weights are similar to low density polyethylene but crystallinities are usually high (50-85%) and densities range from 940 to 960 kg m⁻³. Regarding the production of polyolefins, three main techniques are employed: high pressure technology, solution or slurry processes and gas phase polymerisation.

- **HDPE pipe, extruded:** the dataset describes a standard technology for a HDPE pipe extrusion.
- **HDPE, processed by injection moulding:** the dataset describes a standard technology for HDPE injection moulding.
- **Polyethylene low density granulate (PE-LD)** has traditionally been defined as polyethylene with a density less than 940 kg/m³. It is produced by a high pressure process and so is often referred to as high pressure polyethylene. The polymer contains both long and short chain side branching with the number of branches being from 2 and 50 per 1000 carbon atoms on the carbon backbone. LDPE can be produced with chain lengths ranging from 50,000 to 100,000 repeat units, with crystallinities in the range 35 to 75% and with densities in the range 915 to 940 kg m⁻³.
- **Polyethylene low linear density granulate (PE-LLD)** is a copolymer of ethylene with another short chain olefin. The most common co-monomers are 1-butene, 1-hexene, 4-methyl-1-pentene and 1-octene. The comonomer is usually present in concentrations of 2.5 to 3.5% and this results in densities in the range 915 to 925 kg/m³ with crystallinities of 30 to 45%. The range of molecular weights of LLDPE are considerably narrower than for LDPE and HDPE; typically they lie in the range 50,000 to 200,000.
- **PEX pipe, extruded:** the dataset describes a standard technology for the production of PEX pipe extrusion.

Data cut-off and completeness principles:

- **HDPE, LDPE and LLDPE granulate,** all relevant mass and energy flows are included in the inventory; no specific cut-off rule is applied.
- **HDPE pipes and HDPE processed by injection moulding:** coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Data sources:

- Boustead Model
- Ecoprofile HDPE
- Ecoprofile LDPE
- Ecoprofile LLDPE
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Plastics Europe Association of Plastics Manufacturers, 2006

2.2.1.5. Polyethylene terephthalate (PET)

To fulfill the requirement of the Base Impacts®, two types of PET are provided:

- PET amorph (granulates)
- PET bottle grade, hereby represented by PET processed by injection stretch blow moulding, with the PET-bottle reference flow.

Technology description and included processes:

- **Polyethylene terephthalate granulate (PET, amorph):** The starting compounds for the commercial production of **PET** are ethylene ($\text{CH}_2=\text{CH}_2$) for the production of ethylene glycol and para-xylene for the production of terephthalic acid.

Naphtha cracking produces only a very small quantity of xylenes. Most xylenes are produced either from pyrolysis gasoline, an aromatic rich fraction produced during naphtha cracking or directly from naphtha in a process known as catalytic reforming. In both cases, the basic feedstock is converted into a mixture of products of which the principal components are benzene, toluene and xylenes (the process is often referred to as the BTX process).

Benzene and other aromatics are isolated in the pure state from the output of the reformer by solvent extraction and fractional distillation. The output from xylene production is a mixture of the three forms (isomers) of xylene. Before use in the production of terephthalic acid, the different isomers are separated. Para-xylene is used in the production of terephthalic acid because the "straight" chain structure is best suited to linear polymers.

In practice there are two routes used in the production of PET:

- in the first one, p-xylene is oxidised to terephthalic acid which is then purified. This purified terephthalic acid (PTA) is then reacted with ethylene glycol to produce bis(hydroxyethyl) terephthalate (BHET) with water as a by-product.
- the alternative route, oxidises p-xylene to terephthalic acid but then immediately reacts the acid with methanol to produce dimethyl terephthalate (DMT).

When DMT is reacted with ethylene glycol, the result is again BHET, as in the alternative route, but the by-product is now methanol rather than water. The methanol is recovered and re-used. The monomer from either route can now be polymerised in the liquid phase to produce amorphous PET.

- **PET, processed by injection stretch blow moulding:** the dataset describes a standard technology for the injection stretch blow moulding of Polyethyleneterephthalat.

Data cut-off and completeness principles:

- **PET, amorph:** all relevant mass and energy flows are included in the inventory; no specific cut-off rule is applied.
- **PET processed by injection stretch blow moulding:** coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Data sources:

- Boustead Model
- Ecoprofile PET (amorphous grade)

2.2.1.6. Polymethylmethacrylate-ball (PMMA)

Technology description and included processes:

Unlike the polyolefins, the production route for polymethyl methacrylate requires the production of a significant number of intermediates. Essentially the processes produce acetone cyanohydrin which is then converted to methyl methacrylate. The monomer may be

polymerised to produce beads which can then be extruded, or the monomer may be directly polymerised as in the production of cast sheet.

There are a number of different routes to acetone but the most commonly used is as a by-product in the manufacture of phenol and this route has been used in the present work. Hydrogen cyanide is mainly produced by the reaction of methane (natural gas) with ammonia.

A small proportion of hydrogen cyanide, however, is obtained as a by-product from acrylonitrile production. For the purposes of this profile, it has been assumed that all hydrogen cyanide is produced from the reaction of methane and ammonia.

Acetone is then reacted with hydrogen cyanide to produce acetone cyanohydrin and this is converted to methyl methacrylate in an acid solution of sulphuric acid. The intermediate, methacrylamide sulphate is not isolated but the spent sulphuric acid from the process is recovered and regenerated for further use.

Data cut-off and completeness principles:

All relevant mass and energy flows are included in the inventory; no specific cut-off rule is applied.

Data sources:

- Boustead Model
- Ecoprofile PMMA

2.2.1.7. Polyoxymethylene granulate (POM)

Technology description and included processes:

Polyoxymethylene (POM) is a polymer of formaldehyde, which is produced from methanol. POM is produced by polymerisation. There are homo- and copolymers. Copolymers have more thermostability and chemical resistance .

POM is produced by the following steps: First methanol is oxidised to formaldehyde. By trimerisation of it, trioxane is produced. The next step is the Purification of trioxane. Afterwards copolymerisation of trioxane with cyclic ethers or cyclic acetals is attached followed by the removal of unstable terminal groups. The last step is characterised by the homogenisation of the polymers in melt state.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles".

Data sources:

- Industrial Inorganic Chemistry, 2000
- Industrial Organic Chemistry, 2003
- CD Römpp Chemie Lexikon, 1995
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Die Kunststoffe und ihre Eigenschaften, 2005
- Saechtling Kunststoffaschenbuch, 2004
- Chemische Prozesskunde, 1996
- Handbook of Petrochemicals Production Processes, 2005
- Handbook of Petrochemicals and Processes, 1999
- Best Available Techniques in the Production of Polymers, 2006
- Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000
- Kunststoffkunde, 2000

- Selected Process from Chemical Process Economics, 1998
- GaBi databases 2006
- Außenhandel nach Waren und Ländern 2004, 2005
- Außenhandel nach Waren und Ländern 2003, 2004
- Europäische Statistische Datenbank EUROSTAT, 2005
- Wirtschaftsdaten und Grafiken zu Kunststoffen, 2004
- Produktions- u. Verbrauchsdaten für Kunststoffe in Deutschland unter Einbeziehung der Verwertung 2003
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2002 & 2003, 2004
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2001 & 2002, 2003

2.2.1.8. Polypropylene (PP)

To fulfill the requirement of the Base Impacts®, 3 types of PP are provided:

- PP pipes, extruded
- PP processed by injection moulding
- PP/EPDM (Ethylene Propylene Diene Elastomer) granulate.

Technology description and included processes:

- **Polypropylene granulate (PP):** Three main techniques are employed in the production of polyolefins: high pressure technology, solution or slurry processes and gas phase polymerisation.
 - High pressure technology: When monomer is held at high pressures and temperatures above the polymer melting point, the monomer/polymer mixture can act as a polymerisation medium. Initiators and catalysts can be added to this medium. This technology is used only for LDPE and employs pressures up to 300 MPa and temperatures up to 300°C.
 - Solution or slurry processes: Many low molecular weight, saturated hydrocarbons will dissolve polyolefins. If the temperature is higher than the melting point of the polymer and the concentration of the polymer is low, the polymer will remain as a true solution. However, at lower temperatures and higher concentrations, the polymer will form a suspension or mobile slurry. Using solutions or slurries as the polymerisation medium requires relatively low temperatures (70-110°C) and relatively low pressures (1-5 MPa).
 - Gas phase polymerisation: A gas phase reactor is essentially a fluidised bed of dry polymer particles maintained either by stirring or by passing gas at high speeds through it. Pressures are usually relatively low at ~2MPa and temperatures are usually in the range 70-110°C. A variety of different configurations are used mainly to obtain an acceptable particle size and shape in the final product. Gas phase polymerisation is used for HDPE, PP and LLDPE.
- **PP pipes, extruded:** the dataset describes the standard technology for the production of a PP pipe extrusion profile.

- **PP, processed by injection moulding:** the datasets describe the standard technologies for PP injection moulding.
- **Polypropylene / Ethylene Propylene Diene Elastomer Granulate (PP/EPDM) Mix:** Basic materials for the EPDM production are from steam cracking gained propylene and ethylene fraction. There are existing different processes for polymerisation, which the vapour phase process, the solution process and emulsion process were the most important. The boundary conditions of these single processes are already listed in the respective documentation and thus not further explained here. The mixes are consumption mixes. The German mix represents the main import structure of the accordant plastic materials.

Data cut-off and completeness principles:

For PP granulate, all relevant mass and energy flows are included in the inventory; no specific cut-off rule is applied.

For the other PP forms: Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

- Boustead Model
- Ecoprofile PP
- Industrial Inorganic Chemistry, 2000
- Industrial Organic Chemistry, 2003
- CD Römpp Chemie Lexikon, 1995
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Die Kunststoffe und ihre Eigenschaften, 2005
- Saechtling Kunststoffaschenbuch, 2004
- Chemische Prozesskunde, 1996
- Handbook of Petrochemicals Production Processes, 2005
- Handbook of Petrochemicals and Processes, 1999
- Best Available Techniques in the Production of Polymers, 2006
- Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000
- Kunststoffkunde, 2000
- Selected Process from Chemical Process Economics, 1998
- GaBi databases 2006
- Außenhandel nach Waren und Ländern 2004, 2005
- Außenhandel nach Waren und Ländern 2003, 2004
- Europäische Statistische Datenbank EUROSTAT, 2005
- Wirtschaftsdaten und Grafiken zu Kunststoffen, 2004
- Produktions- u. Verbrauchsdaten für Kunststoffe in Deutschland unter Einbeziehung der Verwertung 2003
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2002 & 2003, 2004
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2001 & 2002, 2003
- Plastics Europe Association of Plastics Manufacturers, 2006
- ULLMANN'S Encyclopedia of Industrial Chemistry

2.2.1.9. Polystyrene (PS)

Technology description and included processes:

The production of styrene monomer can be thought of as replacing one of the hydrogen atoms in ethylene by a benzene ring (C₆H₆). The monomer is then polymerised in a manner similar to polyethylene; that is, the double bonds in the monomer molecules are opened and neighbouring molecules link together to form a chain. The repeat unit, has the same chemical composition as the styrene monomer.

Crude oil refining produces a fraction known as naphtha which contains a mixture of low molecular weight, saturated hydrocarbons of various composition. This is converted into a smaller group of unsaturated hydrocarbons by cracking - a process in which the naphtha is heated to a high temperature in the absence of air, maintained for a short time at this high temperature and then very rapidly cooled back to a low temperature when all of the reactions stop and the mix of products is essentially fixed.

The resulting mixture is then separated into its constituent components by distillation producing principally ethylene (C₂H₄), propylene (C₃H₆), mixed butenes of general formula C₄H₈ and a number of other compounds which find uses elsewhere in the petrochemical plant either as feedstocks or fuels.

The precise mix of products from cracking are determined by a number of factors such as cracker temperature, residence time and the nature of the feedstock and the operation of a cracker can often be adjusted to produce the required mix of products.

Natural gas is also converted into ethylene, propylene, butenes and other products by cracking.

Although benzene is usually present in small quantities in crude oil, its direct extraction is usually uneconomic. However, one by product of naphtha cracking is a liquid usually referred to as pyrolysis gasoline which is high in unsaturated aliphatic and aromatic hydrocarbons. The benzene fraction in pyrolysis gasoline can be extracted by repeated distillation and it is thought that about half of all benzene used in Europe is produced in this way. Benzene is also produced directly from naphtha by a process known as catalytic reforming.

- **Polystyrene granulate (PS):** The crystal form is pure polystyrene with few additives and is used when clarity is required even though it is very brittle.
- **Polystyrene expandable granulate (EPS):** The expandable form is the same as the crystal form except that low molecular mass hydrocarbons, usually pentane, are incorporated into the finished resin. These additives vaporise during subsequent processing to produce a foam.

Data cut-off and completeness principles:

- **Polystyrene granulate (PS):** All relevant mass and energy flows are included in the inventory; no specific cut-off rule is applied.
- **EPS-Foam (expanded polystyrene foam (PS 12)):** Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Data sources:

- Boustead Model
- Ecoprofile GPPS
- Ecoprofile EPS

2.2.1.10. Polyvinylchloride (PVC)

To fulfill the requirement of the Base Impacts®, three types of PVC are provided: high density B-PVC (bulk), E-PVC (emulsion) and S-PVC (suspension) In addition, the tenderer provided the inventories for:

- PVC film, calendered,
- PVC pipe, extruded,
- PVC processed by injection moulding.

Technology description and included processes:

- **Polyvinylchloride resin (B-PVC):** Unlike suspension or emulsion polymerisation, bulk polymerisation is carried out in the complete absence of water, protective colloids or emulsifying agents. This process relies on the fact that the polymer is insoluble in the monomer and precipitates out to form grains that have no tendency to agglomerate.
The main problem is the difficulty in heat removal and this problem is solved by carrying out the polymerisation in two stages. In the first stage, vinyl chloride monomer is mechanically agitated in a vertical autoclave with the appropriate initiators until a conversion of 7-10% is achieved. This first pre-polymerisation step determines the number of particles that will be formed. Heat is removed by continuously condensing the VCM vapour above the liquid reaction mixture. The pre-polymer is then transferred to a horizontal autoclave equipped with a slow paddle. Here, the particles already formed grow by the formation of further polymer. The process is stopped when 70-90% of the monomer has been converted.
- **Polyvinylchloride granulate (Emulsion, E-PVC):** In this process, surfactants (soaps) are used to disperse the vinyl chloride monomer in water. The monomer is trapped inside soap micelles and protected by the soap and polymerisation takes place using water soluble initiators. The process can be either continuous or batch but both lead to a polymer latex which is a very fine suspension of polymer particles (~ 0.1µm diameter) in water. Excess monomer is recovered and recycled and the polymer particles are dried.
- **Polyvinylchloride granulate (Suspension, S-PVC):** Liquid vinyl chloride is insoluble in water and disperses to fine droplets when mechanically agitated. The droplets remain in suspension as long as the agitation continues. Polymerisation is carried out in pressurised vessels under the influence of heat and initiators and/or catalysts, which are soluble in the water. A typical initiator is an organic peroxide. The reaction is exothermic and the heat evolved is carried to the sides of the reaction vessel by the water. Suspensions agents known as protective colloids are added to the reactor to prevent the monomer droplets coalescing and the polymer particles from agglomerating. When the desired conversion is reached, the batch is transferred to a blow down vessel. Several batches may be transferred to this vessel for blending. Unreacted monomer is recovered and recycled back to the polymerisation reactor. The polymer particles are dried.

- **PVC film, calendered:** the dataset represents a standard technology for PVC film calendering.
- **PVC pipe, extruded:** the dataset describes a standard technology for PVC pipe extrusions.
- **PVC, processed by injection moulding:** the dataset describes a standard technology for PVC injection moulding.

Data cut-off and completeness principles:

- B-PVC, E-PVC, S-PVC: All relevant mass and energy flows are included in the inventory; no specific cut-off rule is applied.
- Other: Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Data sources:

- Boustead Model
- Ecoprofile Chlorine
- Ecoprofile Ethylene
- Ecoprofile B-PVC
- Ecoprofile E-PVC
- Ecoprofile S-PVC
- PlasticsEurope Eco-profiles and Environmental Declarations, March 2009
- ULLMANN'S Encyclopedia of Industrial Chemistry

2.2.1.11. Styreneacrylonitrile (SAN)

For details please see "Additional data set documentation" from PlasticsEurope.

2.2.2. Thermoplastics processes

2.2.2.1. Process – Infrared thermoforming

In the Base Impacts®, this process is provided in two versions: one for LD-PE Part (Ceramic at 950°F/510°C); the other for PMMA Part (Quartz at 1400°F/760°C).

The open input flows, should be defined by the user: with 1kg material

Technology description and included processes:

For the technology description please see "Design of a Unit Process: Thermoforming" by Will Jewell, Khanh Van (Amy) Le, Kara Manley, Richard Otis.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles".

2.2.2.2. Process – Plastic extrusion (unspecific)

Technology description and included processes:

The plastic granulate is plasticized in the extruder. After the extruder screw a die is placed, which has the shape of the extrusion profile. **The waste rate of the process is 5%.**

The open input flows, should be defined by the user: with 1,05 kg material

Data cut-off and completeness principles:

For further details please see the document "GaBi Databases Modelling Principles"

Data source:

- Average Industry Data , 1999-2010
- Patent-/ Technical Literature, 1999-2006

2.2.2.3. Process – Plastic injection moulding (unspecific)

Technology description and included processes:

In the injection mould process, plastics are processed as granules, as powder and as profile strings. In general, thermoplasts, duroplasts, and elastomers can be processed. It is not known how many millions of tons of plastics are converted annually into prefabricated parts in the injection mould process.

The injection moulding process takes place in the following sequence: A revolving screw takes granules out of a mass funnel and moves them through its volutions to its tip. The tool is closed, the injection unit moves against the feed bush, the screw presses like a piston the plastified compound into the tool. The cooled injection moulded part falls out of the opened tool, the screw sends new compound its tip, the injection unit lifts away from the jet. The cycle is completed.

The dataset is made for plastic parts where one sprue system is used for one product. **The waste rate of the model is 2%.**

The open input flows, should be defined by the user: with 1,02 kg material

Data cut-off and completeness principles:

For further details please see the document "GaBi Databases Modelling Principles"

Data source:

- Average Industry Data , 1999-2010
- Patent-/ Technical Literature, 1999-2006

2.2.3. Thermosets

2.2.3.1. Epoxy resin

For details please see "Additional data set documentation" from PlasticsEurope

2.2.3.2. Ethylene vinyl acetate copolymer (72% ethylene, 28% vinyl acetate)

Technology description and included processes:

Ethylene vinyl acetate (CAS 24937-78-8, also known as EVA or sometimes simply as "acetate") is the copolymer of ethylene and vinyl acetate. The weight percent vinyl acetate usually varies from 10 to 40% with the remainder being ethylene. It is a polymer that approaches elastomeric materials in softness and flexibility, yet can be processed like other thermoplastics. The material has good clarity and gloss, barrier properties, low-temperature toughness, stress-crack resistance, hot-melt adhesive and heat sealing properties and resistance to UV radiation. EVA has little or no odor and is competitive with rubber and vinyl products in many electrical applications.

Production of Ethylene vinyl acetate: The dataset describes a continuous process. Ethylene, vinyl acetate and recycle gas are compressed and fed to an autoclave at approx. 1300 bar and 40°C. Initiator solutions are injected into the reactor. Approx. 15 % of the monomer is converted and reacted, the reactor effluent of the remaining gas is recycled back. A small amount of purge ethylene is recycled into the ethylene production. Not reacted vinyl acetate is also recycled back. The copolymer melt is extruded and pelletized. The energy supply and the intermediates, precursors and resources are modeled according to German boundaries.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement).

Data sources:

- Industrial Inorganic Chemistry, 2000
- Industrial Organic Chemistry, 2003
- CD Römpp Chemie Lexikon, 1995
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Die Kunststoffe und ihre Eigenschaften, 2005
- Saechtling Kunststoffaschenbuch, 2004
- Chemische Prozesskunde, 1996
- Handbook of Petrochemicals Production Processes, 2005
- Handbook of Petrochemicals and Processes, 1999
- Best Available Techniques in the Production of Polymers, 2006
- Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000
- Kunststoffkunde, 2000
- Selected Process from Chemical Process Economics, 1998
- GaBi databases 2006
- Außenhandel nach Waren und Ländern 2004, 2005
- Außenhandel nach Waren und Ländern 2003, 2004
- Europäische Statistische Datenbank EUROSTAT, 2005
- Wirtschaftsdaten und Grafiken zu Kunststoffen, 2004
- Produktions- u. Verbrauchsdaten für Kunststoffe in Deutschland unter Einbeziehung der Verwertung 2003
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2002 & 2003, 2004
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2001 & 2002, 2003

2.2.3.3. Polytetrafluoroethylene granulate (PTFE) Mix

Technology description and included processes:

Basic materials for the EPDM production are from steam cracking gained propylene and ethylene fraction. There are existing different processes for polymerisation, which the vapour phase process, the solution process and emulsion process were the most important. The

boundary conditions of these single processes are already listed in the respective documentation and thus not further explained here. The mixes are consumption mixes. The German mix represents the main import structure of the accordant plastic materials.

Data cut-off and completeness principles:

Cut-off rules for each unit process: Coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

- Industrial Inorganic Chemistry, 2000
- Industrial Organic Chemistry, 2003
- CD Römpp Chemie Lexikon, 1995
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Die Kunststoffe und ihre Eigenschaften, 2005
- Saechtling Kunststoffaschenbuch, 2004
- Chemische Prozesskunde, 1996
- Handbook of Petrochemicals Production Processes, 2005
- Handbook of Petrochemicals and Processes, 1999
- Best Available Techniques in the Production of Polymers, 2006
- Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000
- Kunststoffkunde, 2000
- Selected Process from Chemical Process Economics, 1998
- GaBi databases 2006
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- Außenhandel nach Waren und Ländern 2003, 2004
- Europäische Statistische Datenbank EUROSTAT, 2005
- Wirtschaftsdaten und Grafiken zu Kunststoffen, 2004
- Produktions- u. Verbrauchsdaten für Kunststoffe in Deutschland unter Einbeziehung der Verwertung 2003
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2002 & 2003, 2004
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2001 & 2002, 2003

2.2.3.4. Polyurethane (PU)

To fulfill the requirement of the Base Impacts®, two types of polyurethane are provided: flexible foam and rigid foam.

For details please see "Additional data set documentation" from PlasticsEurope

2.2.3.5. Polyester resin unsaturated (UP)

Technology description and included processes:

In contrast to other materials it is not simple to list the raw materials for the production of UP resins, according to the application case there will be different raw materials selected. Above all styrene, maleic anhydride, phthalic anhydride, propylene glycol, ethylene glycol must be named. The boundary conditions of these single processes are already listed in the respective documentation and thus not further explained here.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

- Industrial Inorganic Chemistry, 2000
- Industrial Organic Chemistry, 2003
- CD Römpp Chemie Lexikon, 1995
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Die Kunststoffe und ihre Eigenschaften, 2005
- Saechtling Kunststoffaschenbuch, 2004
- Chemische Prozesskunde, 1996
- Handbook of Petrochemicals Production Processes, 2005
- Handbook of Petrochemicals and Processes, 1999
- Best Available Techniques in the Production of Polymers, 2006
- Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000
- Kunststoffkunde, 2000
- Selected Process from Chemical Process Economics, 1998
- GaBi databases 2006
- Außenhandel nach Waren und Ländern 2004, 2005
- Außenhandel nach Waren und Ländern 2003, 2004
- Europäische Statistische Datenbank EUROSTAT, 2005
- Wirtschaftsdaten und Grafiken zu Kunststoffen, 2004
- Produktions- u. Verbrauchsdaten für Kunststoffe in Deutschland unter Einbeziehung der Verwertung 2003
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2002 & 2003, 2004
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2001 & 2002, 2003

2.2.4. Elastomers

2.2.4.1. Butadiene

For details please see "Additional data set documentation" from Plastics Europe.

2.2.4.2. Butyl rubber – Isobutylene Isoprene Rubber (IIR) by emulsion polymerization

Technology description and included processes:

Continuous process, in which isoprene and isobutylene are polymerized using a methyl chloride medium in a screw extruder at a constant pressure under boiling plug-flow conditions, by means of aluminium ethyl chloride catalyst which operates at -50°C to +15°C.

The polymerization mixture progressively forms a sticky, highly viscous mass which is conveyed by the screw to the extruder outlet as polymerization proceeds. The insoluble butyl rubber product is separated at a high concentration (30%) from the mixture of vapors of unreacted monomers and polymerization medium, which are then recycled.

This reaction being very exothermic, cooling is provided by vaporizing a portion of this mixture in a flash tank before supplying to the extruder and returning the vaporized fraction and

recycled vapours to the flash tank successively through a compressor, heat exchanger and throttle valve.

Data cut-off and completeness principles:

Cut-off rules for each unit process: Coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

- Rubber, 3. Synthetic Rubbers: Chapter in Ullmann's Encyclopedia of Industrial Chemistry, 2011
- Patent EP 0209253 A1 - Manufacture of butyl rubber
- Selected Process from Chemical Process Economics, 1998
- ULLMANN'S Encyclopedia of Industrial Chemistry

2.2.4.3. Natural rubber (NR)

Technology description and included processes:

The basic raw material to produce natural rubber (NR) is tapped latex. It is extracted from latex-containing plants. Latex consists of about 30-40% rubber particles and about 55-65% water, as well as small amounts of protein, sterol glycosides, resins, ash, and sugars.

Growing and processing natural rubber is a complex operation. To harvest latex, a slanted strip of bark halfway around the tree and about one third in deep has to be shaved off. The latex then bleeds out of the severed vessels, flows down along the cut until it reaches a spout, and finally drops into a collection cup that will later be drained. About 10% of the latex is processed into a liquid concentrate by removing some of the water and increasing the rubber content to 60%. This is achieved either by spinning the water out of the latex through centrifugal force, by evaporation, or by a method known as creaming. A chemical agent is added to the latex that causes the rubber particles to swell and rise to the liquid's surface. The concentrate is shipped in liquid form to factories, where it is used for coatings, adhesives, and other applications.

Data cut-off and completeness principles:

Cut-off rules for each unit process: Coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

- Industrial Inorganic Chemistry, 2000
- Industrial Organic Chemistry, 2003
- CD Römpp Chemie Lexikon, 1995
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Die Kunststoffe und ihre Eigenschaften, 2005
- Saechtling Kunststoffaschenbuch, 2004
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- Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000
- Kunststoffkunde, 2000
- Selected Process from Chemical Process Economics, 1998

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- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2002 & 2003, 2004
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2001 & 2002, 2003

2.2.4.4. Polybutadiene (PB)

To fulfill the requirement of the Base Impacts®, two types of polyurethane are provided: PB granulate and PB rubber.

Technology description and included processes:

- **Polybutadiene granulate (PB):** Butadiene readily polymerises to yield a polymer with a repeat unit. The polymer contains a double bond and this is useful as a reactive site to form cross links and reactions with other polymers.
- **Polybutadiene rubber:** Besides the natural rubber synthetic polybutadiene (PB) is produced. The balanced material serves as an elastomer component for plastomers like Acryl Nitrile Butadiene Styrene ABS and High Impact Polystyrene PS-HI. It is not a full elastomer like Styrene Butadiene Rubber. The essential raw material for the production of polybutadiene is butadiene. The polymerisation of butadiene is in this viewed process involved with an very low expenditure. You need less than 1.01kg butadiene for 1kg of polybutadiene.

Data cut-off and completeness principles:

- **PB granulates:** All relevant mass and energy flows are included in the inventory; no specific cut-off rule is applied.
- **PB rubber:** coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

- Boustead Model
- Ecoprofile PB
- Industrial Inorganic Chemistry, 2000
- Industrial Organic Chemistry, 2003
- CD Römpp Chemie Lexikon, 1995
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Die Kunststoffe und ihre Eigenschaften, 2005
- Saechtling Kunststoffaschenbuch, 2004
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- Kunststoffkunde, 2000
- Selected Process from Chemical Process Economics, 1998
- GaBi databases 2006
- Außenhandel nach Waren und Ländern 2004, 2005
- Außenhandel nach Waren und Ländern 2003, 2004
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- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2001 & 2002, 2003

2.2.4.5. Styrene

To fulfill the requirement of the Base Impacts®, two types of styrene are provided: SBR (styrene-butadiene rubber) and SBS (styrene butadiene copolymer).

Technology description and included processes:

- **Styrene-Butadiene Rubber (SBR) Mix:** Essential raw materials for Styrene-butadiene-rubber (SBR) production are styrene and butadiene. It must be distinguished between emulsion polymerisation and solution polymerisation, which will be balanced. In this case the less complicating emulsion polymerisation was considered, which referring to the energy consumption must be judged lower than the solution polymerisation.
Styrene, butadiene, water and other materials (like sulphuric acid, rock salt, etc.) are mixed in a reactor, in which the polymerisation starts. After a definite turnover the reaction is stopped, the residual monomers are removed by vacuum stripping and steam stripping. The present emulsion is coagulating, will be washed and is afterwards drying. The mixes are consumption mixes. The German mix represents the main import structure of the accordant plastic materials.
- **Styrene butadiene copolymer (SBS):** Styrene is polymerized batchwise initiated by lithium alkyls using cyclohexane as a solvent. Butadiene is added by the completion of the styrene polymerization. Portion of solvent together with unreacted monomers are flash vaporised.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement).

Data sources:

- Industrial Inorganic Chemistry, 2000
- Industrial Organic Chemistry, 2003
- CD Römpp Chemie Lexikon, 1995
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Die Kunststoffe und ihre Eigenschaften, 2005
- Saechtling Kunststoffaschenbuch, 2004
- Chemische Prozesskunde, 1996
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- Handbook of Petrochemicals and Processes, 1999
- Best Available Techniques in the Production of Polymers, 2006
- Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000
- Kunststoffkunde, 2000
- Selected Process from Chemical Process Economics, 1998
- GaBi databases 2006
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- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2002 & 2003, 2004
- Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2001 & 2002, 2003
- ULLMANN'S Encyclopedia of Industrial Chemistry
- Industrial Organic Chemistry, 2003
- Individual industry data

2.2.5. Resins and fibers

2.2.5.1. Glass fibers

Technology description and included processes:

For the production of glass fibers the glass raw materials are melted (alternative: gas or electrical tank) and extended to fibers by nozzle blowing, centrifugal casting or nozzle drawing process and coated. The process represents a mix of the various processes corresponding to their market share.

Data cut-off and completeness principles:

Cut-off rules for each unit process: Dataset cover at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Data sources:

GaBi databases 2006

2.2.5.2. Carbon fibers short / low strength

Technology description and included processes:

Intermediates for the production of short carbon fibers (CF) are acrylonitrile and methacrylate, processed to polyacrylonitrile fiber (PAN). The carbon fibers are obtained from polyacrylonitrile (PAN) precursor fibers by stabilization treatment, carbonisation (energy intensive step) and eventually a final heat treatment. These carbon fibers are mainly applied to reinforce polymers.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

Industrial Inorganic Chemistry, 2000

Industrial Organic Chemistry, 2003

CD Römpp Chemie Lexikon, 1995

ULLMANN'S Encyclopedia of Industrial Chemistry

Die Kunststoffe und ihre Eigenschaften, 2005

Saechtling Kunststoffaschenbuch, 2004

Chemische Prozesskunde, 1996

Handbook of Petrochemicals Production Processes, 2005

Handbook of Petrochemicals and Processes, 1999

Best Available Techniques in the Production of Polymers, 2006

Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000

Kunststoffkunde, 2000

Selected Process from Chemical Process Economics, 1998

GaBi databases 2006

2.2.5.3. Carbon fiber, long / high strength

Technology description and included processes:

Intermediates for the production of carbon fiber yarn (CF) is mainly polyacrylonitrile, processed into continuous carbon fiber yarn. The carbon fibers are obtained by stabilisation treatment, carbonisation (very energy intensive step) and eventually a final heat treatment. The yarn is air oxidized at 220°C for many hours and converted by thermosetting to an infusible state. These continuous carbon fibers may be applied to structural elements or pressure vessels parts.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

Industrial Inorganic Chemistry, 2000

Industrial Organic Chemistry, 2003

CD Römpp Chemie Lexikon, 1995

ULLMANN'S Encyclopedia of Industrial Chemistry

Die Kunststoffe und ihre Eigenschaften, 2005

Saechtling Kunststoffaschenbuch, 2004

Chemische Prozesskunde, 1996

Handbook of Petrochemicals Production Processes, 2005

Handbook of Petrochemicals and Processes, 1999

Best Available Techniques in the Production of Polymers, 2006

Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000

Kunststoffkunde, 2000

Selected Process from Chemical Process Economics, 1998

GaBi databases 2006

2.2.5.4. Melamine-formaldehyde resin

Technology description and included processes:

Melamine reacts with formaldehyde. The addition of formaldehyde at the amino group is carried out at pH 9 # 10. It takes place very rapidly. One mole of melamine combines with 6 mol of formaldehyde to form hexahydroxymethylmelamine. Melamine itself is only slightly soluble even in hot water. By heating hydroxymethylmelamines cross-links and forms resins that become more insoluble the longer they are heated. The Melamine condenses with formaldehyde in acid solution to form hydroxymethyl compounds. This is followed by a polycondensation, yielding cross-linked products. Melamine resin is a Duroplast.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

Industrial Inorganic Chemistry, 2000

Industrial Organic Chemistry, 2003

CD Römpp Chemie Lexikon, 1995

ULLMANN'S Encyclopedia of Industrial Chemistry

Die Kunststoffe und ihre Eigenschaften, 2005
Saechtling Kunststofftaschenbuch, 2004
Chemische Prozesskunde, 1996
Handbook of Petrochemicals Production Processes, 2005
Handbook of Petrochemicals and Processes, 1999
Best Available Techniques in the Production of Polymers, 2006
Ressourcenschonende Herstellung von Polymerwerkstoffen am Beispiel Polyolefine, 2000
Kunststoffkunde, 2000
Selected Process from Chemical Process Economics, 1998
GaBi databases 2006
Außenhandel nach Waren und Ländern 2004, 2005
Außenhandel nach Waren und Ländern 2003, 2004
Europäische Statistische Datenbank EUROSTAT, 2005
Wirtschaftsdaten und Grafiken zu Kunststoffen, 2004
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Plastics in Europe - An analysis of plastics consumption and recovery in Europe 2001 & 2002, 2003

2.2.5.5. Phenolic resin (45% concentration)

Technology description and included processes:

Phenol- formaldehyde resins are formed by step- growth polymerisation which is either base- or acid catalysed. Reaction temperature is slightly above 100°C. The reaction is highly exothermal.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

ULLMANN'S Encyclopedia of Industrial Chemistry

2.2.5.6. Urea formaldehyde resin in- situ foam

Technology description and included processes:

Urea formaldehyde resin foam is produced by mixing an aqueous resin solution with a foamed up aqueous surfactant solution and by tempering catalytically. Various additives as for example flame retardants were mixed into the solutions to manipulate the characteristics. Foam materials made of urea formaldehyde foam are foamed with transportable foaming device and are dumped into the parts to be dammed by tube or pipe lines. The dataset considers the raw materials, flame retardants as well as the surfactants for the production of the raw material. The foaming device is not included in the dataset. Transports from the factory to the building site are not considered and must be included according to the system boundaries.

Density of the foam is 10 kg/m³.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Data sources:

GaBi databases 2011

Wärmedämmstoffe

2.2.6. Resins and fibers processes

2.2.6.1. Pultrusion

Technology description and included processes:

The pultrusion is a continuous process to produce reinforced polymers. A motor is used as a continuous drive to move the fibers through the different process steps. In this data set carbon fibers are used as reinforcing material and are combined with a thermosetting plastic.

First the carbon fiber coils are uncoiled and braided through the pulling of the drive/motor. Then the carbon fiber is saturated with the resin mixture in a resin bath and is further pulled through the die where the hardening and forming of the reinforced material begins by using a heated steel mold (temperature approx. 120 °C). The mold is heated via electricity using e.g. heating elements. Finally the reinforced polymer is kept in tension by using e.g. caterpillar tracks and is then cut to the required length by a saw.

In the production line, 1% waste of the reinforced polymer is estimated. Excess polymer is squashed out, not merged with the carbon fiber and not filled in the mold. Thus the excess polymer is recirculated. The electricity for heating the mold is based on a calculation and results in the amount of the heat losses of a used steel plate (assumption: heat transfer via natural convection).

The open input flows, should be defined by the user : with 1,01 kg of specific mixture of thermosetting and carbon fiber and 1,72 MJ electricity.

Data cut-off and completeness principles:

Dataset cover at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Data sources:

GaBi databases 2011

The Pultrusion Process

2.2.6.2. Thermocompression

Technology description and included processes:

Thermocompression/Compression molding is commonly used for thermosetting materials. A measured amount of e.g. granulate is fed into the mold cavity. The used heat facilitates the material to soften. High pressure is applied to fill the cavity and enables to obtain the required strength of the material. With the help of the pressure the both heated molds are closed and the forming/hardening of the plastic begins. The hardening of the plastic takes approx. between 5 and 10 minutes. Finally, after opening of the molds, the product has to be cooled.

The energy demand of the heating is provided via use of electricity. The electricity consumption for the heating is based on literature and calculations. The electricity which is needed for the high pressure input is estimated by using the information of the known power demand of the GaBi thermoforming process. The required electricity for cooling the plastic material is also calculated. The preheating process is not regarded in this data set. 1 % of the plastic waste is estimated in the production process.

The open input flows, should be defined by the user: with 1,01 kg of plastic granulate and 7,53 MJ electricity.

Data cut-off and completeness principles:

Dataset cover at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Data sources:

GaBi databases 2011

DESIGN AND ANALYSIS OF A COMPRESSION MOLDED CARBON COMPOSITE

2.2.7. Fillers

2.2.7.1. Carbon black

Technology description and included processes:

Carbon black and soot are formed by pyrolysis or partial combustion of materials containing carbon. Carbon black, unlike soot, is used for a group of well-defined, industrially manufactured products, which are produced under controlled conditions. Carbon black is highly dispersed elemental carbon and, according to specification, consists of extremely small particles.

Production route: Different production routes exist; the most important process today is the furnace black process, which is described in this dataset. Nearly all rubber grades and a significant part of pigment-grade carbon blacks are manufactured by the furnace black process of incomplete combustion.

Petrochemical oil (in the dataset represented by heavy fuel oil at refinery) is the most important feedstock. Natural gas is the most important fuel for the production of thermal energy used. Rubber blacks as well as pigment-grade carbon blacks with much higher specific surface areas and smaller particle sizes can be produced in the furnace black process by adjusting the operating parameters.

Production: The heavy fuel oil feedstock is injected into a high-temperature zone of a furnace. The high temperature is achieved by burning an additional fuel (natural gas) with air. The oxygen is not sufficient for complete combustion of the feedstock, the majority of which is therefore pyrolyzed to form carbon black. The reaction mixture is then quenched with water and the carbon black is collected from the tail gas by a filter system.

General purpose black used for tyres, plastics and primer coatings.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles".

Data sources:

ULLMANN'S Encyclopedia of Industrial Chemistry

BASE IMPACTS® DATA DOCUMENTATION – PLASTICS, RESINS, FIBERS & FILLERS DATASETS

2.2.7.2. Zinc oxide

Technology description and included processes:

The direct process is noted for its simplicity, low cost, and excellent thermal efficiency. It consists of an initial high-temperature reduction (1000 - 1200 °C) of a zinc-containing material (as oxide), the reducing agent being coal. Reduction takes place according to Boudouard's equations: $ZnO + C \rightarrow Zn + CO$, $ZnO + CO \rightarrow Zn + CO_2$, $C + O_2 \rightarrow CO_2$, $CO_2 + C \rightarrow 2CO$. The zinc vapor and the CO gas are then oxidized to zinc oxide and carbon dioxide above the reaction bed or at the furnace exit. Various zinc-containing materials are used, e.g., zinc concentrates, metallization residues, byproduct zinc hydroxide, and above all zinc dross from casting furnaces or galvanizing. The dross must first be treated to remove chloride and lead by heating at ca. 1000 °C in rotary kilns.

Only rotary kilns are now used for the direct process; the use of static furnaces has been discontinued. The zinc content of raw materials is between 60 and 75 %. There are two types of rotary kiln: 1. One type is a long (ca. 30 m), fairly narrow (2.5 m diameter) kiln, heated by gas or oil. The raw material (a mixture of zinc-containing material and coal) is charged continuously either countercurrent or cocurrent to the combustion gases. The residues, which still contain some zinc and unburnt coal, leave the furnace continuously at the end opposite to the feed end. The excess coal is sieved out and recycled. The combustion gases, containing zinc vapor, ZnO, and CO, pass into a chamber where oxidation is completed and large particles of impurities settle out. The gases are then cooled in a heat exchanger or by dilution with air. The zinc oxide is collected in bag filters. 2. The second type of rotary kiln is shorter (5 m) and has a larger diameter (ca. 3 m). Charging is continuous, but the dezincified residues are removed batchwise.

In both cases, operating conditions are controlled to obtain a high yield and to give the required particle shape and size. Provided no contamination is introduced, chemical purity is determined solely by the composition of the raw materials used.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles".

Data sources:

ULLMANN'S Encyclopedia of Industrial Chemistry

2.2.7.3. Zinc oxide (from refined zinc)

Technology description and included processes:

Indirect process: Refined zinc is melted and O₂ is blown over it in order to get ZnO.

Data cut-off and completeness principles:

Dataset cover at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles".

Data sources:

ULLMANN'S Encyclopedia of Industrial Chemistry

2.2.7.4. Sulphur (elemental) at refinery**Technology description and included processes:**

Petroleum refineries are complex plants. The combination and sequence of a large number of processes is usually very specific to the characteristics of the crude oil and the products to be produced. Additional influencing factors are the market demand for the type of products, the available crude oil quality and certain requirements set by authorities the configuration and complexity of a refinery. Simple hydro-skimming refineries can process only a few crude oil qualities and produce few high-quality products. Complex refineries with many conversion plants can process different crude oil types.

Petroleum refinery activities start with the reception of crude oil. After desalting, the crude oil is feeded to the distilling column of the atmospheric distillation (fractionation of the crude oil by separation according to density/ boiling/ condensation areas). The light ends (gases) go up to the head of the column and are employed to the liquid gas system to recover methane and ethane for use as refinery fuel and LPG (propane and butane) as saleable products. This light product separation is done in almost every refinery. These gases can also be used in a steam-reforming process to produce hydrogen, which is needed for the desulphurisation processes, the hydro cracking and to a lesser extent for the isomerisation unit. The straight-run naphtha of the atmospheric distillation, which is taken in the upper trays of the column are spitted and fed to three different processes. The light naphtha fraction is introduced to the chemical sweeten process. Some sweetened naphtha is directly blended in the gasoline pool, the main fraction is sent to the isomerisation unit where the aliphatic paraffins are converted into iso-paraffins with a high octane value. Often there is a de-isopentaniser (distillation) downstream to increase the gain of iso-components. These iso-paraffins are very valuable components for the gasoline production with high RON content. After desulphurisation the heavy naphtha fractions are sent to the reformer for catalytic transformation from aliphatic paraffins to iso-paraffins and from cyclo-paraffins to aromatic compounds, with a reduction of the net calorific value.

The specific feature of this process is the production of hydrogen (the only hydrogen producer besides additional plants, like steam-reforming). The outputs of the isomerisation (often including a de-isopentaniser) and catalytic reforming go to the gasoline blending system and premium or regular gasoline follow as products. Kerosene is directly obtained from the atmospheric distillation and is separately treated from the rest of the middle distillates fraction. The main part of the middle distillates produced in the atmospheric distillation is employed into the hydrofiner (for desulphurisation). The desulphurised product is fed to the middle distillate blender. The residue from the atmospheric distillation is, mainly, introduced to the vacuum distillation. Here there is a distillation in light vacuum gas oil, vacuum gas oil (wax distillate) and vacuum residue. A part of the atmospheric residue is fed into the visbreaker (mild thermal cracking). Small amounts are introduced directly into the heating oil blending system and the asphalt-blowing process. The light gas oil, as a product of the vacuum distillation, goes to the hydrofiner, is desulphurised, and employed to the middle distillate blender. Some of the vacuum distillate, which has been taken from the middle trays of the vacuum distillation, is introduced to the base oil production of lubricants and waxes. Most of it is fed either to a catalytic cracker (first desulphurised) or a hydrocracker, where the feeds are converted into shorter chains by molecule restructuring. The products are gases, gasoline, middle distillates and heavy cycle gas oils (components of the heavy fuel oil).

The gases of the catalytic cracking are treated in an alkylation and polymerisation unit to manufacture additional valuable gasoline components. These processes are used to combine small petroleum molecules into larger ones. Butylene of the catalytic cracker is further used to produce Methyl-Tertiary- Butyl- Ether (MTBE), a product used as octane booster. Sometimes, external purchased bio-ethanol is used instead. The naphtha of the FCC has to be treated in a special desulphurisation process to reduce the high sulphur content. The vacuum residues go into the coking process, which produces gases, gasoline, middle distillates and heating oil. A further product is petroleum coke, which is then purified. The vacuum residue, like some of the atmospheric residue, is also used as feed for the visbreaking, which also produces gases, naphtha, middle distillates and heating oil. The extracted hydrogen sulphides of all desulphurisation processes are fed to a sulphur recovery unit (claus plant) to recover elemental sulphur.

The energy generation (heat, steam and electricity) requires a large amount of fuels. The fuel burned in refineries power plants and incinerators may be refinery gas, heating oil (residual oil), petrol coke and sometimes middle distillates and LPG. Beside purchased natural gas and electricity is employed.

All important material and energy flows (input- output) are shown in the following graph system boundary of the refinery model. The arrangement of these processes varies among refineries, and few, if any, employ all of these processes.

The data set describes a mass-weighted average refinery for the respective country / region. The data set considers the whole supply chain from crude oil exploration / well installation, production, transport to refining operation. If indicated in the process name, some fuels have certain shares of bio-components. The supply of these bio-components (bio-ethanol and bio-diesel) is modelled according to the national / regional situation).

Data cut-off and completeness principles:

Dataset cover at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Data sources:

Basisdaten für ökol. Bilanzierungen - Einsatz von Nutzfzg. in Transport, Landwirtschaft und Bergbau

Autogas in Europe

Aus der Sprache des Öls

Asia-Pacific Diesel Sulphur Matrix

Application for Approval of the Shell Scotford Upgrader 2 Project

Air pollutant emission estimation methods for E-PRTR reporting by refineries

Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP), Statistical data, 2005

Abastecimento de água de uma refinaria de petróleo

Overview of the European Downstream Oil industry

National Brazilian LCI Database

Mineralöl und Umweltschutz

Mineralöl und Raffinerien

Methodology Report: Pilot Study Diesel

Low-Sulfur Gasoline & Diesel

Latin America and the Caribbean Sulphur Levels in Diesel Fuel
Jahresbericht 2008
Improvements in Life Cycle Energy Efficiency and Greenhouse Gas Emissions of corn-Ethanol
Impact of marine fuels quality legislation on EU refineries at the 2020 horizon
How a oil refinery works
Highway, Nonroad, Locomotive, and Marine Diesel Fuel Sulfur Standards
Global Refining Outlook
Gasoline Sulfur Standards
Environmental Impact Assessment
Emissões dos Gases Geradores do Efeito Estufa por Termelctricas no Período 2000 a 2020
Deutscher Beitrag zur besten verfügbaren Techniken in der Raffinerieindustrie
Current and Proposed Sulfur levels in Diesel in Asia, EU and USA
Consumptive Water Use in the Production of Ethanol and Petroleum Gasoline
Comprehensive Multi-Output LCA Model - Refinery
Worldwide Refining Survey 2009
West Asia, Middle East & North Africa Diesel Sulphur Matrix
Well-to-Wheels analysis of future automotive fuels and powertrains in the European context
Toward a Cleaner Future
Study on Oil Refining and Oil Markets
Statistical Review of Global LP Gas
Standards of Performance for Petroleum Refineries
Richtlinie 2003/17/EG des Europäischen Parlaments und des Rates vom 3. März 2003
Richtlinie 2009/28/EG des Europäischen Parlaments und des Rates vom 23. April 2009
Refining Processing Handbook
Refining BREF review - air emissions
Quantificação e Redução de Emissões de gases Efeito estufa numa Refinaria de Petróleo - REPLAN, 2007
Project News and Information
Petroleum Refining - Technology and Economics

C. DATA SOURCES AND QUALITY

2.3. Background system boundaries

WARNING: in the metadata there is to different background system definition, but the one bellow is the more recent and correct.

Electricity: Electricity is modelled according to the individual country-specific situations. The country-specific modelling is achieved on multiple levels. Firstly, individual energy carrier specific power plants and plants for renewable energy sources are modelled according to the current national electricity grid mix. Modelling the electricity consumption mix includes transmission / distribution losses and the own use by energy producers (own consumption of power plants and "other" own consumption e.g. due to pumped storage hydro power etc.), as well as imported electricity. Secondly, the national emission and efficiency standards of the power plants are modelled as well as the share of electricity plants and combined heat and power plants (CHP). Thirdly, the country-specific energy carrier supply (share of imports and / or domestic supply) including the country-specific energy carrier properties (e.g. element and energy content) are accounted for. Fourthly, the exploration, mining/production, processing and transport processes of the energy carrier supply chains are modelled according to the specific situation of each electricity producing country. The different production and processing techniques (emissions and efficiencies) in the different energy producing countries are considered, e.g. different crude oil production technologies or different flaring rates at the oil platforms.

Thermal energy, process steam: The thermal energy and process steam supply is modelled according to the individual country-specific situation with regard to emission standards and considered energy carriers. The thermal energy and process steam are produced at heat plants. Efficiencies for thermal energy production are by definition 100% in relation to the corresponding energy carrier input. For process steam the efficiency ranges from 85%, 90% to 95%. The energy carriers used for the generation of thermal energy and process steam are modelled according to the specific import situation (see electricity above).

Transports: All relevant and known transport processes are included. Ocean-going and inland ship transport as well as rail, truck and pipeline transport of bulk commodities are considered.

Energy carriers: The energy carriers are modelled according to the specific supply situation (see electricity above).

Refinery products: Diesel fuel, gasoline, technical gases, fuel oils, lubricants and residues such as bitumen are modelled with a parameterised country-specific refinery model. The refinery model represents the current national standard in refining techniques (e.g. emission level, internal energy consumption, etc.) as well as the individual country-specific product output spectrum, which can be quite different from country to country. The supply of crude oil is modelled, again, according to the country-specific situation with the respective properties of the resources.

1. Data quality requirements

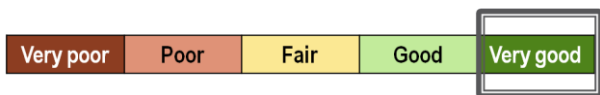
Quality requirements for Base Impacts® datasets are detailed in the general Base Impacts® documentation. No specific quality requirements were set for the plastic datasets.

2. Types and sources of data

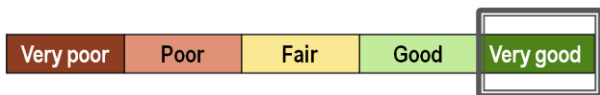
The data sources for the complete product system are sufficiently consistent: primary data from industry was supplemented and validated with different literature data (see technology description for references).

3. Data quality²

3.1. Technological representativeness

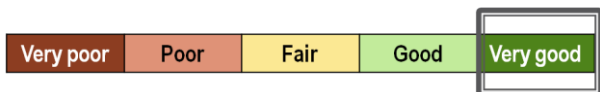


3.2. Time-related coverage

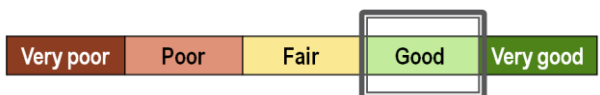


3.3. Geographical coverage

Europe exclusively



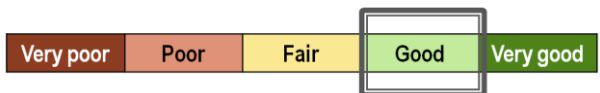
3.4. Precision



3.5. Completeness



3.6. Consistency



² May be updated on resins, fibers and fillers

4. Multi-functionality and allocation procedure

4.1. Foreground system allocation procedure

These datasets do not require allocation procedures.

4.2. Background system allocation procedure

Background system allocation procedure follows the rules defined by PE International.

D. CRITICAL REVIEW

All Base Impacts® datasets follow the ILCD Entry Level requirements, which require a review either internal with public report or external.

The datasets were reviewed by internal critical review:

- Raw data : Validation of data sources, Sample tests on calculations, Cross-check with other source, expert judgment
- Unit process(es), single operation, black box: Energy balance, Element balance, Cross-check with other source, Cross-check with other data set, Mass balance, Compliance with ISO 14040 to 14044
- LCI results or Partly aggregated system: Energy balance, Element balance, Cross-check with other source, Cross-check with other data set, Expert judgment, Mass balance, Compliance with ISO 14040 to 14044
- Impact results : Cross-check with other source, Cross-check with other data set, Expert judgment, Compliance with ISO 14040 to 14044
- Documentation:, Compliance with ISO 14040 to 14044, Documentation
- Inventory methods : Compliance with ISO 14040 to 14044
- Impact results assesment : Expert judgement, Compliance with ISO 14040 to 14044
- Definition of the objectives and scope of the study: expert judgment, compliance with ISO 14040 to 14044
-

E. REPORTS FOR MORE INFORMATION

The following documents should be used for more information:

- Gabi Modelling Principles 2013 ;
- General Base Impacts® documentation
- Review report, available in the metadata of each dataset.

F. ADMINISTRATIVE INFORMATION

1. Commissioner

The datasets were modeled for the following commissioners:

- ADEME
- EC, DG ENV
- EPLCA project team
- PE INTERNATIONAL
- Plastics Europe

2. Dataset modeler

The datasets were modeled by the following modelers:

- Boustead
- PE International
- Plastics Europe

APPENDIX: DATA NEED AND DATA SELECTION

The identified datasets are provided in Base Impacts®, with the following differences between consultation specifications and provided datasets:

Consultation specification	Available datasets	Justification
THERMOPLASTICS - material		
3 types of PE: HDPE, LDPE, LLDPE	idem + processed PE (HDPE pipe, extruded, HDPE, processed by injection moulding, PEX pipe, extruded)	The aggregated dataset include a forming process specific to the polymer type
PP	idem + PP pipe, extruded, + PP, processed by injection moulding, + Polypropylene / Ethylene Propylene Diene Elastomer Granulate (PP/EPDM) Mix	The aggregated dataset include a forming process specific to the polymer type
3 types of PS : GPPS, HIPS, PSE	Polystyrene granulate (PS) Polystyrene expandable granulate (EPS) EPS-Foam (expanded polystyrene foam (PS 12))	No distinction available between GPPS and HIPS polystyrene The aggregated dataset include a forming process specific to the polymer type
3 types of PVC : E-PVC, S-PVC, B-PVC	idem + PVC film, calendered + PVC pipe, extruded + PVC, processed by injection moulding	The aggregated dataset include a forming process specific to the polymer type
THERMOPLASTICS - processes		
foaming	Not provided	The foaming process is present in the database, but aggregated in the data "EPS-Foam (expanded polystyrene foam (PS 12))"
transformation for GPPS and HIPS	Not provided	Data not available
expansion for EPS	Not provided	The expansion process is present in the database, but aggregated in the data "Polystyrene expandable granulate (EPS)"
THERMOSETS - processes		
foaming - flexible	Not provided	The foaming process is present in the database, but aggregated in the data "Polyurethane flexible foam (PU)"
foaming - rigid	Not provided	The foaming process is present in the database, but aggregated in the data

Consultation specification	Available datasets	Justification
		"Polyurethane rigid foam (PU)
ELASTOMERS - material		
Polybutadiene	idem + Polybutadiene rubber	The aggregated dataset include a forming process specific to the polymer type
Silicone	Not provided	Data not available
EPDM	Not provided	Data not available
	Natural rubber (NR)	Data available and relevant
RESINS AND FIBERS		
glass fiber short / low strength long / high strength	Idem	
carbon fiber short / low strength long / high strength	Idem	
melamin-formaldehyde resin	Idem	
phenolic resin	Idem	
urea formaldehyde resin	idem	
RESINS AND FIBERS - PROCESSES		
Pultrusion	Idem	
Thermocompression	idem	
Injection of polymer+30%GF	Plastic injection molding part	Plastic injection molding part provided in order to replace an obsolete injection process
FILLERS (Europe)		
charge : carbon black	Carbon black, Europe	
charge : zinc oxide	Zinc oxide, Europe Zinc oxide from refined zinc, Europe	
charge : sulfur	Sulphur (elemental) at refinery	