

*Eco-profiles of the  
European Plastics Industry*

**POLYURETHANE  
FLEXIBLE FOAM**

*A report by*

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*for*

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*Data last calculated*

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## IMPORTANT NOTE

Before using the data contained in this report, you are strongly recommended to look at the following documents:

### 1. Methodology

This provides information about the analysis technique used and gives advice on the meaning of the results.

### 2. Data sources

This gives information about the number of plants examined, the date when the data were collected and information about up-stream operations.

In addition, you can also download data sets for most of the upstream operations used in this report. All of these documents can be found at: [www.plasticseurope.org](http://www.plasticseurope.org).

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# CONTENTS

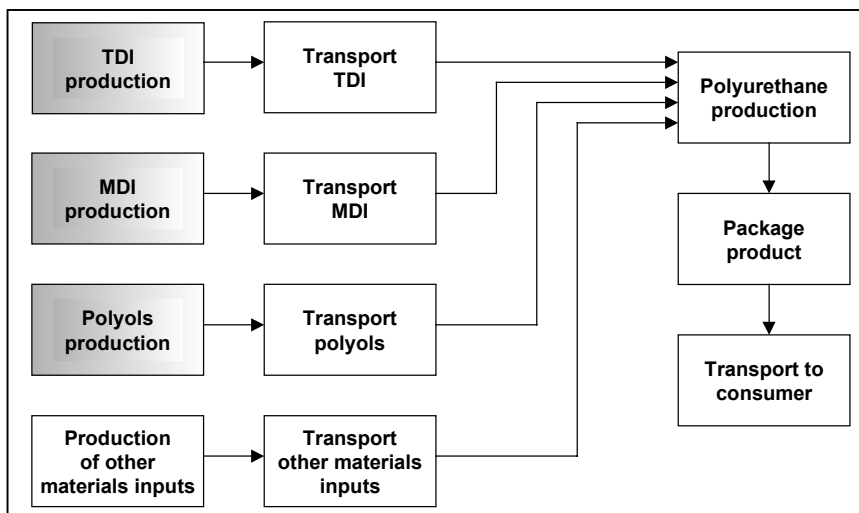
<b>POLYURETHANES .....</b>	<b>4</b>
<b>SAMPLE CALCULATIONS .....</b>	<b>5</b>
PACKAGING POLYURETHANE PRECURSORS.....	6
TRANSPORT OF POLYURETHANE PRECURSORS.....	6
PRODUCTION OF POLYURETHANE PRODUCTS.....	6
<b>PRODUCTION OF A FLEXIBLE FOAM .....</b>	<b>7</b>
<b>RESULTS FOR FLEXIBLE POLYURETHANE FOAM.....</b>	<b>8</b>
<b>POSTSCRIPT .....</b>	<b>17</b>

# POLYURETHANES

A special feature of polyurethanes is their method of production. Generally, metering and mixing two or more streams of liquid components containing polyurethane precursors at the processing stage produces polyurethanes. Thus the final, high molecular weight polymer is normally manufactured by the individual polyurethane processor and not in the plant of the producer of the polyurethane precursors.

Furthermore, the relative amounts of the precursors that have to be combined to produce a specific polyurethane product are usually tailored to the type of product and to the production process. The precise formulations are known to the polyurethane processors but this information is sometimes proprietary and is not commonly known or made available to those outside of the industry. This report is therefore intended to give some general guidance on the use of the data for polyurethane precursors (MDI, TDI and polyols) when attempting to establish data for the full life cycle of polyurethane products.

The sequence of operations used in the production and delivery of polyurethane products is shown in Figure 1.



*Figure 1*  
*Schematic flow chart for the production and delivery of polyurethane products.*

Data for the production of TDI, MDI and polyols, shown shaded in Figure 1, are provided elsewhere as separate reports.

In addition to TDI, MDI and polyols, a number of other chemicals are used in the commercial production of polyurethane products. Additives such as catalysts, surfactants, pigments, etc. are usually added in small quantities

(typically less than 1 to 2%). Data for the production of many of these components are not available and they are often neglected in the calculations. It is common practice to replace them with the main ingredients MDI, TDI and polyols. Thus although their precise production data are not used in the calculations, their substitution by the main ingredients will contribute to the final result and the error will be less than if they were assumed to have zero production energy and emissions, as would be the case if they were simply omitted from the calculations.

However, other additives used in the fabrication of some polyurethane products pose more problems. Flame retardants, which are essential in products used in the building and construction industries, cross linking agents, which are needed to achieve special mechanical properties in elastomeric products, and blowing agents for foams may be used in significant quantities; proportions of 2% to 20% by input mass are common. Neglecting these additives cannot be justified but there is, unfortunately, very little data currently available for the production of these materials. Moreover, it is doubtful whether such information will become available in the near future since they are frequently manufactured by very few companies – in some cases there is only one producer – so that an industry average on a European basis is impossible. Most of these materials are not made by member companies of ISOPA resulting in the additional difficulty of obtaining a commitment from producing companies to engage in the time consuming and potentially costly exercise of collecting LCI data.

There are two approaches that can be used in resolving this problem of chemicals for which data are not available. The first is to use data for a different but chemically similar compound for which data are available. Some care is however needed in this approach because it is possible to replace the unknown chemical by one that has a much simpler production route. The second approach is to replace the unknown chemical by polyurethane precursors; the basis of this assumption is that polyurethane precursors represent a good substitute. Whichever method is adopted it is essential to carry out a sensitivity analysis to ensure that the assumption does not significantly affect the final results for the complete life cycle.

## SAMPLE CALCULATIONS

To illustrate the way in which data for final polyurethane products may be calculated, this report presents some illustrative calculations. It is important to note that the results obtained do not purport to be definitive values for European practice but are expected to be a reasonable approximation to current practice.

### ***Packaging polyurethane precursors***

Processors using large quantities of polyurethane precursors, such as the major producers of thermal insulation foam for the construction industry, usually receive their supplies in bulk tankers by road or rail. The more specialist processors, who use relatively smaller quantities, may receive their supplies in drums.

For polyols, returnable steel drums holding 215 kg are typically of mass 18.5 kg and are expected to last, on average, 1.25 trips before they are lost from the system; that is, only about 20% of the drums are returned and re-used. Although there is a trend towards greater trippage rates, the value of 1.25 trips has been used in the calculations. On this basis, the demand for drums per kg of polyol packed is:

$$18.5/(215 \times 1.25) = 0.069 \text{ kg}$$

Isocyanates are delivered in steel drums of mass 21.5 kg and typically hold 215 kg of product. It is assumed that there is no re-use of isocyanate drums and so the demand for drums per kg of product is

$$21.5/250 = 0.086 \text{ kg}$$

In the calculations, drums have been treated as cold rolled steel and it has been assumed that the inputs and outputs associated with drum fabrication and with drum cleaning are negligible compared with the inputs and outputs associated with the production of the steel.

### ***Transport of polyurethane precursors***

The inputs and outputs associated with the transport of polyurethane precursors depend upon the distance travelled, the type of vehicle and the load carried. In all of the calculations, a nominal one-way transport distance of 100 km has been assumed and it has further been assumed that all deliveries are by road.

Bulk deliveries are assumed to be in fully laden 20 tonne payload road tankers with an empty return load. Drums are assumed to be delivered on 15 tonne payload trucks carrying a load of 10 tonnes.

### ***Production of polyurethane products***

In carrying out an analysis for a specific plant, the precise composition of the product manufactured should be obtained. However, Table 1 gives an indication of the expected compositions of a number of different polyurethane products.

*Table 1*

*Typical input requirements for some polyurethane products. All data are given in parts by weight with ranges shown in parentheses.*

Polyurethane type	Typical application	Polyol	MDI	TDI
Flexible block foam	Furniture Bedding Clothing Leisure goods	100	-	50 (26-56)
Flexible moulded foam	Car seats Furniture			
- hot cure		100	-	40 (33-48)
- cold cure TDI		100	-	40 (35-45)
- cold cure MDI		100	55 (45-65)	-
- cold cure MDI/TDI		100	10 (8-12)	30 (26-34)
Rigid foams	White goods Insulation Building materials Construction	100	160 (150-250)	-
Other automotive				
- semi rigid foam	Dashboards	100	40 (35-50)	
- energy absorbing foams	Bumpers	100	200 (100-300)	
- flexible integral skin foam	Steering wheels	100	40 (35-50)	
- rigid integral skin foam	Door panels	100	150 (120-170)	
- RIM (glycol extended)	Bumpers/panels	100	100 (60-140)	
- RIM (amine extended)	Bumpers/panels	100	50 (40-65)	

## PRODUCTION OF A FLEXIBLE FOAM

To illustrate the method of calculation, consider the production of a flexible PUR-foam blown with water such as might be used in furniture and bedding applications. The inputs and outputs at the production plant might typically be as shown in Table 2.

*Table 2*

*Input-output data for a hypothetical flexible foam producing operation*

Inputs	Water	0.021	kg
	Polyol	0.713	kg
	TDI	0.285	kg
	Electricity	1.500	MJ
Output product	PUR foam	1.000	kg
Air emissions	Carbon dioxide	0.051	kg
Solid waste	Waste foam	0.020	kg

## RESULTS FOR FLEXIBLE POLYURETHANE FOAM

Table 3 shows the gross or cumulative energy to produce 1 kg of flexible polyurethane foam and Table 4 gives this same data expressed in terms of primary fuels. Table 5 shows the energy data expressed as masses of fuels. Table 6 shows the raw materials requirements and Table 7 shows the demand for water. Table 8 shows the gross air emissions and Table 9 shows the corresponding carbon dioxide equivalents of these air emissions. Table 10 shows the emissions to water. Table 11 shows the solid waste generated and Table 12 gives the solid waste in EU format.

*Table 3*

*Gross energy required to produce and deliver 1 kg of flexible polyurethane foam. (Totals may not agree because of rounding)*

Fuel type	Fuel prod'n & delivery energy (MJ)	Energy content of delivered fuel (MJ)	Energy use in transport (MJ)	Feedstock energy (MJ)	Total energy (MJ)
Electricity	15.76	7.11	0.41	-	23.28
Oil fuels	0.55	14.45	0.26	17.82	33.08
Other fuels	1.86	28.16	0.10	15.65	45.78
Totals	18.16	49.73	0.77	33.47	102.14

*Table 4*

*Gross primary fuels required to produce and deliver 1 kg of flexible polyurethane foam. (Totals may not agree because of rounding)*

Fuel type	Fuel prod'n & delivery energy (MJ)	Energy content of delivered fuel (MJ)	Fuel use in transport (MJ)	Feedstock energy (MJ)	Total energy (MJ)
Coal	5.00	5.09	0.10	0.06	10.26
Oil	1.40	14.84	0.49	17.90	34.63
Gas	4.30	24.51	0.09	15.48	44.39
Hydro	0.45	0.24	0.01	-	0.70
Nuclear	6.06	2.78	0.07	-	8.91
Lignite	0.25	0.47	<0.01	-	0.73
Wood	<0.01	<0.01	<0.01	<0.01	<0.01
Sulphur	<0.01	<0.01	<0.01	0.03	0.03
Biomass (solid)	0.38	0.79	<0.01	<0.01	1.17
Hydrogen	<0.01	0.52	<0.01	-	0.52
Recovered energy	<0.01	0.33	<0.01	-	0.33
Unspecified	<0.01	<0.01	<0.01	-	<0.01
Peat	<0.01	<0.01	<0.01	-	<0.01
Geothermal	0.04	0.02	<0.01	-	0.06
Solar	<0.01	<0.01	<0.01	-	<0.01
Wave/tidal	<0.01	<0.01	<0.01	-	<0.01
Biomass (liquid/gas)	0.09	0.04	<0.01	-	0.13
Industrial waste	0.05	0.02	<0.01	-	0.07
Municipal Waste	0.10	0.05	<0.01	-	0.15
Wind	0.03	0.02	<0.01	-	0.05
Totals	18.16	49.73	0.77	33.47	102.13



*Table 5  
Gross primary fuels used to  
produce and deliver 1 kg of  
flexible polyurethane foam  
expressed as mass.*

Fuel type	Input in mg
Crude oil	770000
Gas/condensate	860000
Coal	360000
Metallurgical coal	2600
Lignite	48000
Peat	130
Wood	540

*Table 6  
Gross raw materials required to produce  
and deliver 1 kg of flexible polyurethane  
foam.*

Raw material	Input in mg
Air	360000
Animal matter	<1
Barytes	380
Bauxite	1200
Bentonite	81
Biomass (including water)	150000
Calcium sulphate (CaSO <sub>4</sub> )	8
Chalk (CaCO <sub>3</sub> )	<1
Clay	4
Cr	7
Cu	<1
Dolomite	310
Fe	1200
Feldspar	550
Ferromanganese	1
Fluorspar	22
Granite	<1
Gravel	4
Hg	2
Limestone (CaCO <sub>3</sub> )	430000
Mg	<1
N <sub>2</sub>	130000
Ni	<1
O <sub>2</sub>	100000
Olivine	11
Pb	3
Phosphate as P <sub>2</sub> O <sub>5</sub>	1800
Potassium chloride (KCl)	9500
Quartz (SiO <sub>2</sub> )	<1
Rutile	<1
S (bonded)	<1
S (elemental)	3400
Sand (SiO <sub>2</sub> )	1800
Shale	23
Sodium chloride (NaCl)	1500000
Sodium nitrate (NaNO <sub>3</sub> )	<1
Talc	<1
Unspecified	<1
Zn	1

*Table 7*

*Gross water consumption required for the production and delivery of 1 kg of flexible polyurethane foam. (Totals may not agree because of rounding)*

Source	Use for processing (mg)	Use for cooling (mg)	Totals (mg)
Public supply	57000000	<1	57000000
River canal	31000000	186000000	217000000
Sea	590000	15000000	15000000
Well	560000	4900000	5500000
Unspecified	6500000	46000000	53000000
Totals	95000000	252000000	347000000

Table 8

Gross air emissions associated with the production and delivery of 1 kg of flexible polyurethane foam. (Totals may not agree because of rounding)

Emission	From fuel prod'n (mg)	From fuel use (mg)	From transport (mg)	From process (mg)	From biomass (mg)	From fugitive (mg)	Totals (mg)
dust (PM10)	1300	340	15	4700	-	-	6400
CO	2800	1100	170	1300	-	-	5400
CO2	1200000	2300000	26000	560000	-180000	-	3900000
SOX as SO2	6000	6200	210	370	-	-	13000
H2S	<1	-	<1	<1	-	-	<1
mercaptan	<1	<1	<1	<1	-	-	<1
NOX as NO2	3500	4900	240	630	-	-	9200
NH3	<1	-	<1	240	-	-	240
Cl2	<1	<1	<1	310	-	-	310
HCl	140	38	<1	13	-	-	190
F2	<1	<1	<1	<1	-	-	<1
HF	5	1	<1	<1	-	-	6
hydrocarbons not specified	1500	540	67	1100	-	<1	3200
aldehyde (-CHO)	<1	-	<1	<1	-	-	<1
organics	<1	<1	<1	860	-	-	860
Pb+compounds as Pb	<1	<1	<1	<1	-	-	<1
Hg+compounds as Hg	<1	-	<1	<1	-	-	<1
metals not specified elsewhere	1	4	<1	<1	-	-	5
H2SO4	<1	-	<1	<1	-	-	<1
N2O	<1	19	<1	<1	-	-	19
H2	200	<1	<1	1800	-	-	2000
dichloroethane (DCE) C2H4Cl2	<1	-	<1	<1	-	<1	<1
vinyl chloride monomer (VCM)	<1	-	<1	<1	-	<1	<1
CFC/HCFC/HFC not specified	<1	-	<1	10	-	-	10
organo-chlorine not specified	<1	-	<1	13	-	-	13
HCN	<1	-	<1	1	-	-	1
CH4	30000	930	<1	1900	-	<1	33000
aromatic HC not specified	<1	-	1	69	-	<1	71
polycyclic hydrocarbons (PAH)	<1	<1	<1	2	-	-	2
NMVOC	<1	-	<1	6	-	-	6
CS2	<1	-	<1	1	-	-	1
methylene chloride CH2Cl2	<1	-	<1	<1	-	-	<1
Cu+compounds as Cu	<1	<1	<1	<1	-	-	<1
As+compounds as As	-	-	-	<1	-	-	<1
Cd+compounds as Cd	<1	-	<1	<1	-	-	<1
Ag+compounds as Ag	-	-	-	<1	-	-	<1
Zn+compounds as Zn	<1	-	<1	<1	-	-	<1
Cr+compounds as Cr	<1	<1	<1	<1	-	-	<1
Se+compounds as Se	-	-	-	<1	-	-	<1
Ni+compounds as Ni	<1	<1	<1	<1	-	-	<1
Sb+compounds as Sb	-	-	<1	<1	-	-	<1
ethylene C2H4	-	-	<1	1	-	-	1
oxygen	-	-	-	<1	-	-	<1
asbestos	-	-	-	<1	-	-	<1
dioxin/furan as Teq	-	-	-	<1	-	-	<1
benzene C6H6	-	-	-	<1	-	1	1
toluene C7H8	-	-	-	<1	-	<1	<1
xylene C8H10	-	-	-	<1	-	<1	<1
ethylbenzene C8H10	-	-	-	<1	-	<1	<1
styrene	-	-	-	<1	-	<1	<1
propylene	-	-	-	1	-	-	1

*Table 9*

*Carbon dioxide equivalents corresponding to the gross air emissions for the production and delivery of 1 kg of flexible polyurethane foam. (Totals may not agree because of rounding)*

Type	From fuel prod'n (mg)	From fuel use (mg)	From transport (mg)	From process (mg)	From biomass (mg)	From fugitive (mg)	Totals (mg)
20 year equiv	3100000	2300000	26000	680000	-180000	<1	5900000
100 year equiv	1900000	2300000	26000	610000	-180000	<1	4700000
500 year equiv	1400000	2300000	26000	580000	-180000	<1	4100000

Table 10

Gross emissions to water arising from the production and delivery of 1 kg of flexible polyurethane foam. (Totals may not agree because of rounding).

Emission	From fuel prod'n (mg)	From fuel use (mg)	From transport (mg)	From process (mg)	Totals (mg)
COD	6	<1	<1	2900	2900
BOD	1	<1	<1	490	490
Pb+compounds as Pb	<1	-	<1	<1	<1
Fe+compounds as Fe	<1	-	<1	8	8
Na+compounds as Na acid as H+	<1	-	<1	430000	430000
NO3-	6	-	<1	4	11
Hg+compounds as Hg	<1	<1	<1	7800	7800
metals not specified elsewhere	<1	-	<1	<1	<1
ammonium compounds as NH4+	2	-	<1	52	54
Cl-	6	<1	<1	430	440
CN-	1	<1	<1	830000	830000
F-	<1	-	<1	1	1
S+sulphides as S	<1	-	<1	1	<1
dissolved organics (non-suspended solids)	1	-	<1	170	170
detergent/oil	100	-	26	42000	42000
hydrocarbons not specified	<1	<1	<1	9	9
organo-chlorine not specified	10	<1	<1	93	100
dissolved chlorine	<1	-	<1	2	2
phenols	<1	-	<1	1	1
dissolved solids not specified	<1	-	<1	<1	<1
P+compounds as P	<1	-	<1	6900	6900
other nitrogen as N	<1	<1	<1	690	690
other organics not specified	1	<1	<1	2100	2100
SO4--	<1	<1	<1	230	230
dichloroethane (DCE)	<1	<1	<1	5500	5500
vinyl chloride monomer (VCM)	<1	-	<1	<1	<1
K+compounds as K	<1	-	<1	<1	<1
Ca+compounds as Ca	<1	-	<1	130	130
Mg+compounds as Mg	<1	-	<1	120000	120000
Cr+compounds as Cr	<1	-	<1	150	150
ClO3--	<1	-	<1	7	7
BrO3--	<1	-	<1	110	110
TOC	<1	-	<1	<1	<1
AOX	<1	-	<1	850	850
Al+compounds as Al	<1	-	<1	23	23
Zn+compounds as Zn	<1	-	<1	1	1
Cu+compounds as Cu	<1	-	<1	2	2
Ni+compounds as Ni	<1	-	<1	<1	<1
CO3--	<1	-	<1	<1	<1
As+compounds as As	-	-	<1	1700	1700
Cd+compounds as Cd	-	-	<1	<1	<1
Mn+compounds as Mn	-	-	<1	<1	<1
organo-tin as Sn	-	-	<1	<1	<1
Sr+compounds as Sr	-	-	<1	<1	<1
organo-silicon	-	-	-	<1	<1
benzene	-	-	-	<1	<1
dioxin/furan as Teq	-	-	<1	<1	<1
Mo+compounds as Mo	-	-	-	<1	<1

*Table 11*

*Gross solid waste associated with the production and delivery of 1 kg of flexible polyurethane foam. (Totals may not agree because of rounding)*

Emission	From fuel prod'n (mg)	From fuel use (mg)	From transport (mg)	From process (mg)	Totals (mg)
Plastic containers	<1	-	<1	<1	<1
Paper	<1	-	<1	3	3
Plastics	<1	-	<1	20000	20000
Metals	<1	-	<1	79	79
Putrescibles	<1	-	<1	<1	<1
Unspecified refuse	1700	-	<1	<1	1700
Mineral waste	12000	-	260	110000	130000
Slags & ash	24000	8000	100	2800	35000
Mixed industrial	-2000	-	10	24000	22000
Regulated chemicals	2100	-	<1	33000	35000
Unregulated chemicals	1600	-	<1	7600	9200
Construction waste	<1	-	<1	68	68
Waste to incinerator	<1	<1	<1	20000	20000
Inert chemical	<1	-	<1	1700	1700
Wood waste	<1	-	<1	8	8
Wooden pallets	<1	-	<1	<1	<1
Waste to recycling	<1	-	<1	150	150
Waste returned to mine	66000	-	10	1200	67000
Tailings	2	-	9	240	250
Municipal solid waste	-14000	-	-	<1	-14000

Note: Negative values correspond to consumption of waste e.g. recycling or use in electricity generation.

Table 12

Gross solid waste in EU format associated with the production of 1 kg of flexible polyurethane foam. Entries marked with an asterisk (\*) are considered hazardous as defined by EU Directive 91/689/EEC

Emission	Totals (mg)
010101 metallic min'l excav'n waste	75000
010102 non-metal min'l excav'n waste	110000
010306 non 010304/010305 tailings	240
010308 non-010307 powdery wastes	10
010399 unspecified met. min'l wastes	30000
010408 non-010407 gravel/crushed rock	1
010410 non-010407 powdery wastes	44
010411 non-010407 potash/rock salt	1700
010499 unsp'd non-met. waste	4200
010505*oil-bearing drilling mud/waste	2000
010508 non-010504/010505 chloride mud	1600
010599 unspecified drilling mud/waste	1700
020107 wastes from forestry	8
030399 unsp'd wood/paper waste	1
050106*oil ind. oily maint'e sludges	9
050107*oil industry acid tars	160
050199 unspecified oil industry waste	230
050699 coal pyrolysis unsp'd waste	140
060101*H2SO4/H2SO3 MFSU waste	4
060102*HCl MFSU waste	<1
060106*other acidic MFSU waste	<1
060199 unsp'd acid MFSU waste	<1
060204*NaOH/KOH MFSU waste	<1
060299 unsp'd base MFSU waste	2000
060313*h. metal salt/sol'n MFSU waste	2400
060314 other salt/sol'n MFSU waste	350
060399 unsp'd salt/sol'n MFSU waste	780
060404*Hg MFSU waste	130
060405*other h. metal MFSU waste	430
060499 unsp'd metallic MFSU waste	990
060602*dangerous sulphide MFSU waste	<1
060603 non-060602 sulphide MFSU waste	7
060701*halogen electrol. asbestos waste	34
060702*Cl pr. activated C waste	<1
060703*BaSO4 sludge with Hg	13
060704*halogen pr. acids and sol'ns	57
060799 unsp'd halogen pr. waste	1000
061002*N ind. dangerous sub. waste	<1
061099 unsp'd N industry waste	<1
070101*organic chem. aqueous washes	<1
070103*org. halogenated solv'ts/washes	<1
070104*other organic solv'ts/washes	<1
070107*hal'd still bottoms/residues	37000
070108*other still bottoms/residues	3900
070111*org. chem. dan. eff. sludge	<1
070112 non-070111 effluent sludge	1
070199 unsp'd organic chem. waste	4200

continued over .....

Table 12 - continued

Gross solid waste in EU format associated with the production of 1 kg of flexible polyurethane foam. Entries marked with an asterisk (\*) are considered hazardous as defined by EU Directive 91/689/EEC

070204*polymer ind. other washes	<1
070207*polymer ind. hal'd still waste	<1
070208*polymer ind. other still waste	10000
070209*polymer ind. hal'd fil. cakes	<1
070213 polymer ind. waste plastic	20000
070214*polymer ind. dan. additives	150
070215 non-0702130 additive waste	<1
070216 polymer ind. silicone wastes	<1
070299 unsp'd polymer ind. waste	160
080199 unspecified paint/varnish waste	<1
100101 non-100104 ash, slag & dust	28000
100102 coal fly ash	1900
100104*oil fly ash and boiler dust	78
100105 FGD Ca-based reac. solid waste	<1
100113*emulsified hydrocarbon fly ash	21
100114*dangerous co-incin'n ash/slag	14
100115 non-100115 co-incin'n ash/slag	91
100116*dangerous co-incin'n fly ash	<1
100199 unsp'd thermal process waste	1500
100202 unprocessed iron/steel slag	340
100210 iron/steel mill scales	16
100399 unspecified aluminium waste	22
100501 primary/secondary zinc slags	1
100504 zinc pr. other dust	<1
100511 non-100511 Zn pr. skimmings	<1
100899 unspecified o.n.f.m. waste	<1
101304 lime calcin'n/hydration waste	11
110199 unspecified surf. t waste	<1
130208*other engine/gear/lub. oil	<1
150101 paper and cardboard packaging	2
150102 plastic packaging	<1
150103 wooden packaging	<1
150106 mixed packaging	52
150110*dan. sub. contam'd packaging	<1
150202*dan. sub. absorbents	<1
160807*spent dangerous sub. catalyst	<1
170107 non-170106 con'e/brick/tile mix	<1
170405 iron and steel	<1
170904 non-170901/2/3 con./dem'n waste	68
190199 unspecified incin'n/pyro waste	<1
190905 sat./spent ion exchange resins	1700
200101 paper and cardboard	<1
200108 biodeg. kitchen/canteen waste	<1
200138 non-200137 wood	<1
200139 plastics	120
200140 metals	76
200199 other separately coll. frac'ns	-3700
200301 mixed municipal waste	96
200399 unspecified municipal wastes	-12000
Note: Negative values correspond to consumption of waste e.g. recycling or use in electricity generation.	



## POSTSCRIPT

All life cycle inventories are concerned with describing the behaviour of industrial systems, not products; a product is simply one materials flow within the system. The system itself is identified in terms of its function. Consequently if any comparisons are to be attempted, then they must be confined to comparing systems that perform identical functions. This is the basis of all life cycle assessments. Despite this requirement, which has been stated many times, there are still some users of life cycle inventories who continue to compare materials on the basis of 1 kg of polyurethane versus 1 kg of some other material. Such comparisons are meaningless.

Also, when comparing systems, which perform equivalent functions, it is important to compare the data for the whole life cycle and not just data for those elements of the life cycle that differ. Comparison of parts of systems can lead to misleading conclusions. For example, if polyurethane foam is used to insulate a house, the value of the exercise is demonstrated by a comparison of the system describing the un-insulated house with that describing the insulated house. Essentially the investment of a small amount of energy and feedstock in the production of the foam insulant leads to a saving of at least 100 times this initial investment in heating fuels over the lifetime of the house. The investment of 1 unit of energy results in a saving of 99 units. If a different type of insulant is used with a production energy that is 25% greater than the polyurethane, the net energy saving will be 98.75 units for every 1.25 units of initial investment.

Such a comparison indicates that the important feature is to install insulation materials of any type to achieve the saving of energy. Comparing the insulation materials on the basis of their production energies is a marginal exercise of little value since the difference in production energies of different materials is trivial compared with the ultimate saving.



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