



PlasticsEurope
Association of Plastics Manufacturers

*Eco-profiles of the
European Plastics Industry*

ETHYL BENZENE

A report by

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for

PlasticsEurope

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.

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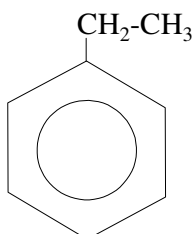
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ETHYL BENZENE

Ethyl benzene has the structure:



It is now almost always produced by the direct, liquid phase reaction of ethylene with benzene using an aluminium chloride catalyst.

It is estimated that about 99% of all ethyl benzene is subsequently used for the production of styrene.¹

ECO-PROFILE OF ETHYL BENZENE

Table 1 shows the gross or cumulative energy to produce 1 kg of ethyl benzene and Table 2 gives this same data expressed in terms of primary fuels. Table 3 shows the energy data expressed as masses of fuels. Table 4 shows the raw materials requirements and Table 5 shows the demand for water. Table 6 shows the gross air emissions and Table 7 shows the corresponding carbon dioxide equivalents of these air emissions. Table 8 shows the emissions to water. Table 9 shows the solid waste generated and Table 10 gives the solid waste in EU format.

Table 1

Gross energy required to produce 1 kg of ethyl benzene. (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 | 2.84 | 0.90 | 0.36 | - | 4.10 |
| Oil fuels | 0.26 | 12.00 | 0.10 | 27.65 | 40.00 |
| Other fuels | 0.40 | 5.48 | 0.02 | 16.77 | 22.67 |
| Totals | 3.50 | 18.39 | 0.48 | 44.41 | 66.78 |

¹ Chenier, P.J. *Survey of Industrial Chemistry*. ISBN 1-56081-082-3. VCH Publishers. (1992)

Table 2

Gross primary fuels required to produce 1 kg of ethyl benzene. (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 | 0.73 | 1.41 | 0.12 | <0.01 | 2.26 |
| Oil | 0.70 | 12.16 | 0.15 | 27.65 | 40.66 |
| Gas | 1.01 | 8.80 | 0.11 | 16.77 | 26.69 |
| Hydro | 0.07 | 0.04 | <0.01 | - | 0.11 |
| Nuclear | 0.94 | 0.35 | 0.09 | - | 1.37 |
| Lignite | <0.01 | <0.01 | <0.01 | - | <0.01 |
| Wood | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Sulphur | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Biomass (solid) | 0.01 | <0.01 | <0.01 | <0.01 | 0.02 |
| Hydrogen | <0.01 | 0.01 | <0.01 | - | 0.01 |
| Recovered energy | <0.01 | -4.40 | <0.01 | - | -4.40 |
| Unspecified | <0.01 | <0.01 | <0.01 | - | <0.01 |
| Peat | <0.01 | <0.01 | <0.01 | - | <0.01 |
| Geothermal | <0.01 | <0.01 | <0.01 | - | <0.01 |
| Solar | <0.01 | <0.01 | <0.01 | - | <0.01 |
| Wave/tidal | <0.01 | <0.01 | <0.01 | - | <0.01 |
| Biomass (liquid/gas) | 0.02 | <0.01 | <0.01 | - | 0.03 |
| Industrial waste | <0.01 | <0.01 | <0.01 | - | <0.01 |
| Municipal Waste | 0.01 | <0.01 | <0.01 | - | 0.02 |
| Wind | <0.01 | <0.01 | <0.01 | - | <0.01 |
| Totals | 3.50 | 18.39 | 0.48 | 44.41 | 66.78 |

Table 3

Gross primary fuels used to produce 1 kg of ethyl benzene expressed as mass.

| Fuel type | Input in mg |
|--------------------|-------------|
| Crude oil | 900000 |
| Gas/condensate | 530000 |
| Coal | 79000 |
| Metallurgical coal | 130 |
| Lignite | 5 |
| Peat | 82 |
| Wood | 9 |

Table 4
Gross raw materials required to produce 1 kg of ethyl benzene.

| Raw material | Input in |
|--|----------|
| Air | 270000 |
| Animal matter | <1 |
| Barytes | 1 |
| Bauxite | 850 |
| Bentonite | 89 |
| Biomass (including water) | 5100 |
| Calcium sulphate (CaSO ₄) | 9 |
| Chalk (CaCO ₃) | <1 |
| Clay | <1 |
| Cr | <1 |
| Cu | 7 |
| Dolomite | 4 |
| Fe | 330 |
| Feldspar | <1 |
| Ferromanganese | <1 |
| Fluorspar | 16 |
| Granite | <1 |
| Gravel | 1 |
| Hg | <1 |
| Limestone (CaCO ₃) | 390 |
| Mg | <1 |
| N ₂ | 190000 |
| Ni | <1 |
| O ₂ | 9 |
| Olivine | 3 |
| Pb | <1 |
| Phosphate as P ₂ O ₅ | <1 |
| Potassium chloride (KCl) | 7 |
| Quartz (SiO ₂) | <1 |
| Rutile | <1 |
| S (bonded) | <1 |
| S (elemental) | 87 |
| Sand (SiO ₂) | 140 |
| Shale | 25 |
| Sodium chloride (NaCl) | 2100 |
| Sodium nitrate (NaNO ₃) | <1 |
| Talc | <1 |
| Unspecified | <1 |
| Zn | <1 |

Table 5
Gross water consumption required for the production of 1 kg of ethyl benzene. (Totals may not agree because of rounding)

| Source | Use for processing (mg) | Use for cooling (mg) | Totals (mg) |
|---------------|-------------------------|----------------------|-------------|
| Public supply | 590000 | - | 590000 |
| River canal | 160000 | 1600000 | 1800000 |
| Sea | 560000 | 5800000 | 6300000 |
| Well | <1 | 83000 | 83000 |
| Unspecified | 710000 | 70000000 | 71000000 |
| Totals | 2000000 | 78000000 | 80000000 |

Table 6

Gross air emissions associated with the production of 1 kg of ethyl benzene.

(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) | 230 | 99 | 2 | 180 | - | - | 510 |
| CO | 970 | 830 | 18 | 440 | - | - | 2300 |
| CO2 | 230000 | 1100000 | 8200 | 200000 | -8 | - | 1600000 |
| SOX as SO2 | 1100 | 2400 | 130 | 460 | - | - | 4100 |
| H2S | <1 | - | <1 | <1 | - | - | <1 |
| mercaptan | <1 | <1 | <1 | <1 | - | - | <1 |
| NOX as NO2 | 970 | 1600 | 50 | 220 | - | - | 2900 |
| NH3 | <1 | - | <1 | <1 | - | - | <1 |
| Cl2 | <1 | <1 | <1 | 1 | - | - | 1 |
| HCl | 20 | 8 | <1 | <1 | - | - | 28 |
| F2 | <1 | <1 | <1 | <1 | - | - | <1 |
| HF | 1 | <1 | <1 | <1 | - | - | 1 |
| hydrocarbons not specified | 700 | 160 | 15 | 1200 | - | 3 | 2000 |
| aldehyde (-CHO) | <1 | - | <1 | <1 | - | - | <1 |
| organics | <1 | <1 | <1 | 240 | - | - | 240 |
| Pb+compounds as Pb | <1 | <1 | <1 | <1 | - | - | <1 |
| Hg+compounds as Hg | <1 | - | <1 | <1 | - | - | <1 |
| metals not specified elsewhere | <1 | 1 | <1 | <1 | - | - | 2 |
| H2SO4 | <1 | - | <1 | <1 | - | - | <1 |
| N2O | <1 | <1 | <1 | <1 | - | - | <1 |
| H2 | 24 | <1 | <1 | 27 | - | - | 51 |
| dichloroethane (DCE) C2H4Cl2 | <1 | - | <1 | <1 | - | <1 | <1 |
| vinyl chloride monomer (VCM) | <1 | - | <1 | <1 | - | <1 | <1 |
| CFC/HCFC/HFC not specified | <1 | - | <1 | <1 | - | - | <1 |
| organo-chlorine not specified | <1 | - | <1 | 1 | - | - | 1 |
| HCN | <1 | - | <1 | <1 | - | - | <1 |
| CH4 | 13000 | 230 | <1 | 2200 | - | <1 | 15000 |
| aromatic HC not specified elsewhere | <1 | - | <1 | 18 | - | 3 | 21 |
| polycyclic hydrocarbons (PAH) | <1 | 5 | <1 | <1 | - | - | 5 |
| NM VOC | <1 | - | <1 | 35 | - | - | 35 |
| 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 | 2 | <1 | <1 | - | - | 2 |
| Se+compounds as Se | - | - | - | <1 | - | - | <1 |
| Ni+compounds as Ni | <1 | 5 | <1 | <1 | - | - | 5 |
| Sb+compounds as Sb | - | - | <1 | <1 | - | - | <1 |
| ethylene C2H4 | - | - | <1 | 8 | - | - | 8 |
| oxygen | - | - | - | <1 | - | - | <1 |
| asbestos | - | - | - | <1 | - | - | <1 |
| dioxin/furan as Teq | - | - | - | <1 | - | - | <1 |
| benzene C6H6 | - | - | - | 6 | - | 14 | 21 |
| toluene C7H8 | - | - | - | <1 | - | 2 | 3 |
| xylenes C8H10 | - | - | - | <1 | - | 1 | 1 |
| ethylbenzene C8H10 | - | - | - | 1 | - | 1 | 2 |
| styrene | - | - | - | <1 | - | <1 | <1 |
| propylene | - | - | - | 6 | - | - | 6 |

Table 7

Carbon dioxide equivalents corresponding to the gross air emissions for the production of 1 kg of ethyl benzene. (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 | 1000000 | 1100000 | 8300 | 350000 | -8 | 39 | 2500000 |
| 100 year equiv | 530000 | 1100000 | 8300 | 260000 | -8 | 19 | 1900000 |
| 500 year equiv | 320000 | 1100000 | 8300 | 220000 | -8 | 12 | 1700000 |

Table 8

Gross emissions to water arising from the production of 1 kg of ethyl benzene.
(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 | 1 | - | <1 | 220 | 220 |
| BOD | <1 | - | <1 | 46 | 46 |
| Pb+compounds as Pb | <1 | - | <1 | <1 | <1 |
| Fe+compounds as Fe | <1 | - | <1 | <1 | <1 |
| Na+compounds as Na | <1 | - | <1 | 200 | 200 |
| acid as H+ | 1 | - | <1 | 2 | 3 |
| NO3- | <1 | - | <1 | 5 | 5 |
| Hg+compounds as Hg | <1 | - | <1 | <1 | <1 |
| metals not specified elsewhere | <1 | - | <1 | 130 | 130 |
| ammonium compounds as NH4+ | 1 | - | <1 | 3 | 4 |
| Cl- | <1 | - | <1 | 240 | 240 |
| CN- | <1 | - | <1 | <1 | <1 |
| F- | <1 | - | <1 | <1 | <1 |
| S+sulphides as S | <1 | - | <1 | <1 | <1 |
| dissolved organics (non- | <1 | - | <1 | 5 | 5 |
| suspended solids | 20 | - | 2 | 120 | 140 |
| detergent/oil | <1 | - | <1 | 25 | 25 |
| hydrocarbons not specified | 11 | <1 | <1 | 1 | 12 |
| organo-chlorine not specified | <1 | - | <1 | <1 | <1 |
| dissolved chlorine | <1 | - | <1 | <1 | <1 |
| phenols | <1 | - | <1 | <1 | <1 |
| dissolved solids not specified | <1 | - | <1 | 61 | 61 |
| P+compounds as P | <1 | - | <1 | 1 | 1 |
| other nitrogen as N | <1 | - | <1 | 3 | 3 |
| other organics not specified | <1 | - | <1 | <1 | <1 |
| SO4-- | <1 | - | <1 | 370 | 370 |
| dichloroethane (DCE) | <1 | - | <1 | <1 | <1 |
| vinyl chloride monomer (VCM) | <1 | - | <1 | <1 | <1 |
| K+compounds as K | <1 | - | <1 | <1 | <1 |
| Ca+compounds as Ca | <1 | - | <1 | 18 | 18 |
| Mg+compounds as Mg | <1 | - | <1 | <1 | <1 |
| Cr+compounds as Cr | <1 | - | <1 | <1 | <1 |
| ClO3-- | <1 | - | <1 | 1 | 1 |
| BrO3-- | <1 | - | <1 | <1 | <1 |
| TOC | <1 | - | <1 | 37 | 37 |
| AOX | <1 | - | <1 | <1 | <1 |
| Al+compounds as Al | <1 | - | <1 | 1 | 1 |
| Zn+compounds as Zn | <1 | - | <1 | <1 | <1 |
| Cu+compounds as Cu | <1 | - | <1 | 1 | 1 |
| Ni+compounds as Ni | <1 | - | <1 | 1 | 1 |
| CO3-- | - | - | <1 | 120 | 120 |
| As+compounds as As | - | - | <1 | <1 | <1 |
| 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 |

Table 9

*Gross solid waste associated with the production of 1 kg of ethyl benzene.
(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 | <1 | <1 |
| Plastics | <1 | - | <1 | 4 | 4 |
| Metals | <1 | - | <1 | <1 | <1 |
| Putrescibles | <1 | - | <1 | <1 | <1 |
| Unspecified refuse | 930 | - | <1 | <1 | 930 |
| Mineral waste | 13 | - | 21 | 810 | 850 |
| Slags & ash | 2900 | 850 | 8 | 1600 | 5300 |
| Mixed industrial | 700 | - | 1 | 350 | 1100 |
| Regulated chemicals | 1100 | - | <1 | 88000 | 89000 |
| Unregulated chemicals | 860 | - | <1 | 260 | 1100 |
| Construction waste | <1 | - | <1 | 42 | 42 |
| Waste to incinerator | <1 | - | <1 | 7000 | 7000 |
| Inert chemical | 250 | - | <1 | 1100 | 1300 |
| Wood waste | <1 | - | <1 | <1 | <1 |
| Wooden pallets | <1 | - | <1 | <1 | <1 |
| Waste to recycling | <1 | - | <1 | 130 | 130 |
| Waste returned to mine | 15000 | - | 1 | 1400 | 17000 |
| Tailings | <1 | - | 1 | 290 | 290 |
| Municipal solid waste | -1700 | - | - | 500 | -1200 |
| Note: Negative values correspond to consumption of waste e.g. recycling or use in electricity generation. | | | | | |

Table 10

Gross solid waste in EU format associated with the production of 1 kg of ethyl benzene. 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 | 1100 |
| 010102 non-metal min'l excav'n waste | 16000 |
| 010306 non 010304/010305 tailings | 7 |
| 010308 non-010307 powdery wastes | 1 |
| 010399 unspecified met. min'l wastes | 2 |
| 010408 non-010407 gravel/crushed rock | <1 |
| 010410 non-010407 powdery wastes | <1 |
| 010411 non-010407 potash/rock salt | 10 |
| 010499 unsp'd non-met. waste | 3 |
| 010505*oil-bearing drilling mud/waste | 1100 |
| 010508 non-010504/010505 chloride mud | 860 |
| 010599 unspecified drilling mud/waste | 930 |
| 020107 wastes from forestry | <1 |
| 050106*oil ind. oily maint'e sludges | 1 |
| 050107*oil industry acid tars | 210 |
| 050199 unspecified oil industry waste | 180 |
| 050699 coal pyrolysis unsp'd waste | 16 |
| 060101*H ₂ SO ₄ /H ₂ SO ₃ MFSU waste | <1 |
| 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 | <1 |
| 060313*h. metal salt/sol'n MFSU waste | 9 |
| 060314 other salt/sol'n MFSU waste | 1 |
| 060399 unsp'd salt/sol'n MFSU waste | 440 |
| 060404*Hg MFSU waste | <1 |
| 060405*other h. metal MFSU waste | 1 |
| 060499 unsp'd metallic MFSU waste | 3 |
| 060602*dangerous sulphide MFSU waste | <1 |
| 060603 non-060602 sulphide MFSU waste | <1 |
| 060701*halogen electrol. asbestos waste | <1 |
| 060702*Cl pr. activated C waste | <1 |
| 060703*BaSO ₄ sludge with Hg | <1 |
| 060704*halogen pr. acids and sol'ns | 2 |
| 060799 unsp'd halogen pr. waste | 5 |
| 061002*N ind. dangerous sub. waste | <1 |
| 061099 unsp'd N industry waste | <1 |
| 070101*organic chem. aqueous washes | 87000 |
| 070103*org. halogenated solv'ts/washes | <1 |
| 070107*hal'd still bottoms/residues | <1 |
| 070108*other still bottoms/residues | 6100 |
| 070111*org. chem. dan. eff. sludge | <1 |
| 070112 non-070111 effluent sludge | 10 |
| 070199 unsp'd organic chem. waste | 1400 |
| 070204*polymer ind. other washes | <1 |
| 070207*polymer ind. hal'd still waste | <1 |
| 070208*polymer ind. other still waste | 140 |

continued over

Table 10 - continued

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

| | |
|---|------|
| 070209*polymer ind. hal'd fil. cakes | 42 |
| 070213 polymer ind. waste plastic | 3 |
| 070214*polymer ind. dan. additives | 180 |
| 070216 polymer ind. silicone wastes | <1 |
| 070299 unsp'd polymer ind. waste | 220 |
| 080199 unspecified paint/varnish waste | <1 |
| 100101 non-100104 ash, slag & dust | 3700 |
| 100102 coal fly ash | 320 |
| 100104*oil fly ash and boiler dust | <1 |
| 100105 FGD Ca-based reac. solid waste | 250 |
| 100113*emulsified hyrdocarbon fly ash | <1 |
| 100114*dangerous co-incin'n ash/slag | 1100 |
| 100115 non-100115 co-incin'n ash/slag | 1 |
| 100116*dangerous co-incin'n fly ash | 98 |
| 100199 unsp'd themal process waste | 75 |
| 100202 unprocessed iron/steel slag | 98 |
| 100210 iron/steel mill scales | 7 |
| 100399 unspecified aluminium waste | 16 |
| 100501 primary/secondary zinc slags | <1 |
| 100504 zinc pr. other dust | <1 |
| 100511 non-100511 Zn pr. skimmings | <1 |
| 101304 lime calcin'n/hydration waste | 13 |
| 130208*other engine/gear/lub. oil | <1 |
| 150101 paper and cardboard packaging | <1 |
| 150102 plastic packaging | <1 |
| 150103 wooden packaging | <1 |
| 150106 mixed packaging | <1 |
| 170107 non-170106 con'e/brick/tile mix | <1 |
| 170904 non-170901/2/3 con./dem'n waste | 42 |
| 190199 unspecified incin'n/pyro waste | <1 |
| 190905 sat./spent ion exchange resins | 1100 |
| 200101 paper and cardboard | <1 |
| 200108 biodeg. kitchen/canteen waste | <1 |
| 200138 non-200137 wood | <1 |
| 200139 plastics | 1 |
| 200140 metals | <1 |
| 200199 other separately coll. frac'ns | -230 |
| 200301 mixed municipal waste | 3 |
| 200399 unspecified municipal wastes | -290 |
| Note: 1. Negative values correspond to consumption of waste e.g. recycling or | |